RESPONSE OF DIVERSE WINTER WHEAT TYPES

TO PRODUCTION PRACTICES

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

TABLE Page

LIST OF FIGURES

LIST OF FIGURES (Continued)

FIGURES | Page

INTRODUCTION

Most present winter wheat production recommendations are based on the standard varieties. The standard varieties are characterized by moderate to tall height, early to medium maturity, low to medium grain protein percentage and moderate to high yield potential. During the last several years, however, new wheats, whose plant types differ from the standard varieties, have been introduced. These new types include early maturing varieties, semidwarf varieties, high protein varieties and, most recently, hybrids. In some cases, several of these traits are combined in one variety.

We compared responses of the new wheat plant types to what we considered the most important production factors -- seeding date, seeding rate, and nitrogen fertilization -- at Manhattan and to seeding rate and nitrogen fertilization at two additional Kansas locations. The objective was to determine applicability of recommended production practices based on standard varieties to the new wheat types.

REVIEW OF LITERATURE

Seeding Date

Recommended seeding dates for the Central Great Plains have been established for the standard varieties (Vanderlip and Lawless, 1977; Bieberly, 1963; Anonymous, 1970; Anonymous, 1975a). Yield has been the main criterion for these recommendations. Kolp et al. (1973), in Wyoming, found seeding date had no significant effect on yield but Ferguson and Finkner (1969), in New Mexico, found early seeding date was superior to late and normal seeding dates. Very late dates drastically decreased yields (Ferguson and Finkner, 1969). Seeding date and rate frequently interacted so that high seeding rates partially compensated for late seeding dates (Kolp et al., 1973; Ferguson and Finkner, 1969; Anonymous, 1970). Low yields at late seeding dates were attributed to poor stands after emergence and to increased winterkill (Paulsen and Painter, 1977; Vanderlip and Lawless, 1977). Kolp et al. (1973) found seedlings from early and late seeding dates were more susceptable to winter injury than seedlings from normal dates. That disagreed with Vanderlip and Lawless (1977), in Kansas, who suggested early seeding was conducive to increased tillering, a deeper root system and less susceptability to winter injury.

Early seeding has other advantages and disadvantages for grain yield. Early seeding increased soil moisture depletion (Vanderlip and Lawless, 1977; Kolp et al., 1973), especially when coupled with a high seeding rate (Kolp et al., 1973). Kolp et al. (1973) found the effects of seeding date and rate on soil moisture depletion were not significant when the whole year was considered. They found the highest seeding rate and earliest seeding date caused the most soil moisture depletion in the fall but the least in the spring. Decreasing

top growth, either by lowering seeding rates or pasturing early-seeded wheat, would decrease soil moisture depletion and offset another disadvantage to early planting -- increased insect and disease damage (Bieberly, 1963). Ferguson and Finkner (1969), in New Mexico, found early seeding at high seeding rates was necessary for wheat that was to be used for both forage (pasture) and grain. Early seeding date increased tillering, which resulted in more top growth for pasture and more heads for grain yield.

Wheat grain protein concentration was significantly affected by seeding date. Late seeding date increased protein percentage (Kolp et al., 1973). Rate and date interacted, resulting in the highest protein concentration at the lowest seeding rate and latest seeding date (Kolp et al., 1973).

Seeding Rate

Recommended seeding rates have been established in the Central Great Plains for the standard varieties (Bieberly, 1963; Anonymous, 1970; Anonymous, 1975a). Ferguson and Finkner (1969) found heavier rates increased yield in New Mexico but the advantage in yield with increased seeding rate was not always marked. On the other hand, Kolp et al. (1973) found no significant difference in grain yield among rates or dates tested. Low seeding rates were best in Western Kansas because conditions there are conducive to tillering (Anonymous, 1975a). Pastured wheat required high seeding rates for optimum vegetation, optimum tiller numbers, and optimum grain yield (Ferguson and Finkner, 1969). Poor quality seed caused low emergence, reduced tillering and reduced heads. High seeding rate increased the emergence of shriveled grain (Anonymous, 1975a).

Paulsen and Painter (1977), in Kansas, suggested that high seeding rates increase top growth and lodging, both of which might increase disease and insect problems by establishing a favorable microclimate for infestation.

Low seeding rates were recommended for areas with low soil moisture such as the Western Central Great Plains (Anonymous, 1976). However, low seeding rates in areas with favorable moisture and nutrients were suggested to increase weed infestation (Paulsen and Painter, 1977).

Protein concentration of the grain was highly significantly affected by seeding rate (Kolp et al., 1973). Kolp et al. (1973) found seeding rate x date interacted for grain protein concentration; lowest rate and latest date gave the highest protein concentration of the grain.

Nitrogen Rate

Recommended nitrogen rates were established in the Central Great Plains for the standard varieties (Orazem, Murphy, and Whitney, 1974; Anonymous, 1975a). Nitrogen was the most frequently lacking nutrient for optimum wheat production (Anonymous, 1975a). Thompson (1976), in Kansas, found nitrogen caused the greatest positive effect on grain yield. Hucklesby et al. (1971) found that increased nitrogen rate increased grain yield for all varieties tested. Hunter and Stanford (1973) and Standford and Hunter (1973), in Pennsylvania, Clapp (1973), in North Carolina, and Orazem et al. (1974), in Kansas, found wheat grain yields increased up to an optimum nitrogen rate but decreased with excess nitrogen. The optimum nitrogen rate differed with variety and area (Laopirojana, Roberts, and Dawson, 1972; Tweedy, Kern, Kapusta, and Millis, 1971; Johnson, Dreier, and Gradouski, 1973; Stanford and Hunter, 1973; Hunter and Stanford, 1973). Differences were noted particularly with some of the new semidwarf and high protein varieties (Johnson et al., 1973; Hucklesby et al., 1971). However, yields of standard varieties seldom increased significantly with more than 68 kg of nitrogen per hectare under Great Plains conditions (Johnson et al., 1973).

Clapp (1973), in North Carolina, explained high nitrogen rate depressed grain yields by delaying maturity and increasing rust infestation. Both

Clapp (1973) and Laopirojana et al. (1972), in Oregon, reported high nitrogen rates increased vegetative growth (tillers), a major factor in depleting the soil of moisture for grain filling. Increased lodging with high rates of nitrogen also decreased yield (Anonymous, 1975a; Stickler and Pauli, 1964). Increased yield with increased nitrogen was most often agreed to be a result of increased tillering (Stickler and Pauli, 1964; Hobbs, 1953; Clapp, 1973). Hobbs (1953), in Kansas, found increased seeds per head with spring top-dressed nitrogen while Stickler and Pauli (1964), in Kansas, found little effect of nitrogen on seeds per head unless at a very high rate of nitrogen.

Stanford and Hunter (1973) and Hunter and Stanford (1973), in Pennsylvania, found that the nitrogen requirements of two soft winter wheat cultivars were the same. The two did not differ in their nitrogen uptake by the whole plants per unit of grain at the optimum nitrogen rate. Stickler and Pauli (1964), in Kansas, found only a slight (nonsignificant) difference in varietal response to nitrogen among four hard red winter wheat varieties due to the higher disease resistance of one variety and the high disease susceptability of another variety. They concluded varieties of similar adaptation could be expected to exhibit equal response to fertilization but, when their adaptation differed greatly, differential response was more likely.

The effect of nitrogen rate on seed weight has not been studied. Laopirojana et al. (1972), in Oregon, found increased nitrogen rates decreased test weights. Johnson et al. (1973), in Nebraska, found regression of nitrogen on test weight was negative and linear. Clapp (1973), in North Carolina, found a nitrogen rate of 112 kg per hectare decreased test weights, and Hobbs (1953), in Kansas, found the effect of nitrogen on test weight was nonsignificant.

All researchers agreed that increased nitrogen rates increased grain protein concentration regardless of effect on yield (Laopirojana et al., 1972;

Hobbs, 1953; Tweedy et al., 1971; Hucklesby et al., 1971; Johnson et al., 1973; Hunter and Stanford, 1973; Anonymous, 1976; Thompson, 1976).

Varietal Response

A large number of wheat varieties are recommended for the Central Great Plains (Anonymous, 1975a; Anonymous, 1976; Bieberly, 1963). Yield potential, disease resistance, plant height and lodging are reported for these varieties in state variety trial reports or bulletins. Stickler and Pauli (1964), in Kansas, working with four standard varieties of hard red winter wheat, found a highly significant variety effect for yield due to higher tillering capacity and higher seed weight of one wariety. They also found a slight (nonsignificant) differential varietal response to nitrogen but attributed that to differences in susceptability to soil-borne mosaic virus, leaf and stem rust and Hessian fly among the varieties. High nitrogen in the soil predisposed plants to disease by increasing succulence, stand density, and lodging and by delaying maturity (Stickler and Pauli, 1964).

Early maturing varieties have been postulated to have an advantage for yield, especially in the South Central Great Plains (Anonymous, 1976). Wheat usually exhausts soil moisture by maturity. Early maturing varieties had a better chance to fill their grain before soil moisture was depleted and before summer temperatures were extremely high (Anonymous, 1976). Ferguson and Finkner (1969), in New Mexico, studied dryland yield of two winter wheat varieties differing in maturity. They found no significant yield differences between varieties or for seeding date or seeding rate interaction with variety. Similarly, Ketata, Edwards, and Morrison (1976), in Oklahoma, found no significant differences in yield among varieties that were very early, early, and mid-season in maturity. However, they found fertile tillers, kernels per spike, kernel weight, test weight, plant height, maturity and protein concentration of the grain differed significantly among varieties.

The main advantage attributed to semidwarf wheat types has been the assumed higher yields resulting from the higher nitrogen rates possible without lodging of the short, stiff straw (Clapp, 1973; Laopirojana et al., 1972). Increased yields, however, have not always resulted from high rates of nitrogen applied to semidwarf wheats (Clapp, 1973; Laopirojana et al., 1972). Both Clapp (1973) and Laopirojana et al. (1972) found that high nitrogen rates depressed yields after an optimum level even with semidwarf varieties. They agreed that high rates of nitrogen stimulated dry matter accumulation (vegetative growth or tillering) to a greater degree than grain filling could be supported under existing soil moisture conditions. Clapp (1973) also found depressed yields were due in part to increased rust infestation with high nitrogen application. Increased nitrogen application on semidwarf wheats increased grain protein percentage at all levels of nitrogen (Hucklesly et al., 1971; Laopirojana et al., 1972).

Stanford and Hunter (1973) and Hunter and Stanford (1973), working with the same semidwarf and medium tall varieties in Pennsylvania, found that the internal nitrogen requirements for the two varieties was the same. That is, the two varieties, even though they differed in yield, did not differ in the quantity of nitrogen taken up by the whole plants per unit of grain production at optimum nitrogen rates. Hucklesby et al. (1971) showed the modern semidwarf wheats at the appropriate level and timing of nitrogen application had very high yield potential plus high percentage of good quality grain protein.

In the past, protein concentration of the grain was believed to be related inversely to yield (Hucklesby et al., 1971). Recently, with the introduction of new high protein wheats, the validity of that statement was challenged. Genes which increase the protein potential of wheat have been found, but their inheritance is not simple and the degree of their expression depended upon the interaction with several factors of the environment and

production, especially available soil nitrogen (Heyne, 1977; Johnson et al., 1973). Seed Research Inc. (Heyne, 1977), in Kansas, defined three classes of high protein wheat. Class I wheats were consistently higher in grain protein percentage under all conditions. These included 'Atlas 66'-derived lines. Class II wheats were often higher in protein percentage and Class III wheats included most of the standard varieties grown today. Johnson et al. (1973), in Nebraska, found a high protein Atlas 66-derived variety and an average protein variety which differed inherently in protein percentage had the same positive linear protein response to nitrogen. The Atlas 66-derived variety was two percent higher in grain protein percentage than the average protein variety at all levels of nitrogen due to more efficient and complete translocation of nitrogen from the vegetation to the grain. Although the variety x nitrogen interaction was significant for yield, grain protein percentage was independent of yield (Johnson et al., 1973; Hucklesby et al., 1971). The possible improvement of grain protein percentage and yield simultaneously by nitrogen application and the need for nitrogen rates above 90 kg per hectare for field assessment of varietal response to soil fertility levels were demonstrated (Johnson et al., 1973).

The yield advantages of heterosis have revolutionized sorghum and corn production world wide. These same yield advantages are now claimed for hybrid wheats (Hayward, 1975; Livers and Heyne, 1968). Hybrid wheat yields have been shown to exceed non-hybrid yields by at least 20% (Anonymous, 1975; Anonymous, 1976; Livers and Heyne, 1968). High yielding parents with high genetic diversity result in the maximum expression of heterosis (Livers and Heyne, 1968). Most hybrid wheats are adapted to specific locations.

Several researchers (Hayward, 1975; Anonymous, 1975) have reported that seeding rates of adapted hybrids can be reduced by as much as 50% of those recommended for standard wheats without a significant decrease in yield due

to hybrid vigor in emergence, vigor and tillering capacity. Others indicate hybrids do not yield well at low seeding rates (Hayward, 1975).

Hybrid wheats have shown a significant protein advantage over non-hybrids (Anonymous, 1975).

Inefficient male-fertility restoration often reduces the potential yield capacity of hybrid wheats (Jost and Milhonic, 1975; Hayward, 1975; Johnson and Schmidt, 1968).

MATERIALS AND METHODS

Seven hard red winter wheat (Triticum aestivium L. em. Thell.) varieties and hybrids were selected for the study. They were 'Sage', a tall, medium-maturity variety with high yield potential; 'Trison', a tall early-maturity variety with high yield potential; 'Lancota', a tall-medium-maturity variety with high grain protein potential; 'Plainsman V', a semidwarf, very early-maturity variety with high grain protein potential; 'Funk W-335', a semidwarf, medium-maturity variety with high yield potential; 'Pioneer HR915A', a medium-maturity hybrid wheat; and 'Prairie Valley 4450', an early-maturity hybrid wheat. The wheats were grown at Hutchinson in southcentral Kansas, at Colby in northwest Kansas, and at Manhattan in northeast Kansas. One date of seeding was used at the first two locations and three dates of seeding were used at Manhattan. Five seeding rates and five nitrogen fertilizer rates were compared at all locations. The study was conducted during the 1976 and 1977 crop years.

The wheat was planted at Hutchinson on October 3, 1975, and October 2, 1976, and at Colby on September 24 both years. At Manhattan, the early, normal and late seeding dates during 1975 and 1976, respectively, were September 10 and September 22, October 6, and October 7, and November 18 and November 16. The five seeding rates, 17, 34, 50, 67, and 101 kg/ha (15, 30, 45, 60, and 90 lbs/acre, respectively), and the five nitrogen fertilizer rates, 0, 34, 67, 101, and 134 kg/ha (0, 30, 60, 90, and 120 lbs/acre, respectively) were arranged in an incomplete factorial of 13 treatment combinations at all locations. A split-plot design with varieties as main plots and treatment combinations as sub-plots was used at Hutchinson and Colby. The experimental design at Manhattan was a split-split-plot design with seeding dates as main plots, varieties as sub-plots and treatment combinations as sub-sub-plots. Three replications were used at all locations. Each sub-plot at Hutchinson and Colby

and each sub-sub-plot at Manhattan was 1.2m x 10m (4 ft. x 33 ft.) and contained six rows spaced 20 cm (8 in.) apart. The wheat was planted with a KEM plot drill and nitrogen as ammonium nitrate was top-dressed during late winter of 1976 and 1977.

The soil types were clay loam at Hutchinson and Colby and silt loam at Manhattan. Available soil nitrogen (nitrate plus ammonia) in samples taken prior to seeding was 31 and 26 ppm at Hutchinson, 7 and 9 ppm at Colby, and 22 and 22 ppm at Manhattan during 1975 and 1976, respectively. Different fields were used at Hutchinson and Colby during the two years while, at Manhattan, plots were re-established on the exact same site the second year.

The weather differed for the 1976 and 1977 crop years. The 1976 crop at Hutchinson and Manhattan produced ample fall top growth under warm to cool (moderate) temperatures until late December and early January. Planting and seedling emergence and development were handicapped severely at Colby by droughty conditions during the fall of 1975. The 1977 crop year was nearly opposite with very little top growth in the fall and extremely cold temperatures in October resulting in winter dormancy at the three-leaf stage. Both winters were hard and cold with little snow cover but no winterkill occurred. It was unseasonably warm in February and March both seasons, and extremely dry in 1977 compared to the average. April and May of 1976 were cool and a late frost occurred on May 8 in Manhattan that severely reduced yield of the earliest variety, 'Plainsman V', in Manhattan. In 1977, the month of April was exceedingly dry however, later precipitation was generally adequate. Harvest was normal in 1976 but a long rainy period in 1977 complicated harvest.

Plant measurements in Manhattan included fertile tillers per meter of row, weed infestation, flowering date, Barley Yellow Dwarf Virus (BYDV) infestation and plant height. Tiller count was taken just prior to harvest both years. Plant height was measured in centimeters from the ground to the tip of the head

and weed and BYDV infestation were measured as per cent of the plot infested. BYDV measurements were taken during 1976 only. Tiller counts and plant height were measured at Colby and Hutchinson during 1977 only.

Plots were harvested with a KEM plot combine. Areas harvested were 10.59 m^2 and 11.15 m^2 at Hutchinson, 10.59 m^2 and 10.59 m^2 at Colby, and 10.04 m^2 and 0.8 m^2 at Manhattan during 1976 and 1977, respectively.

Grain measurements taken in Hutchinson, Colby and Manhattan both years included yield per plot, 100-seed weight and protein percentage at 14% moisture. Test weights were determined on grain from all plots except those harvested at Manhattan during 1977. Percent protein of the grain was determined by the macro Kjeldahl procedure.

Statistical analysis included analysis of variance, correlation analysis and regression analysis. Data were fitted to a two-independent variable cubic regression model (Y = Bo + s + n + s x s + n x n + s x s x n + s x n x n + s x s x s + n x n x n) and fitted regression equations were used to plot surface response graphs of yield, protein percentage and test weight to seeding rate and nitrogen rate treatments for each variety at each location and seeding date. The graphs do not have a common nor zero baseline. Baselines were fixed at the lowest value for yield, protein percentage or test weight for each variety at each location and seeding date individually. The scale for the z axis was determined seperately for each variety at each location and seeding date by the computer. One z unit equals the range in yield (kg/ha), protein percentage or test weight (kg/hl) divided by 30% of the range of nitrogen rate (30% of 134). Seeding rate and nitrogen rate are in kg/ha for all graphs. The graphs can be misinterpreted. They should be viewed with analysis of variance at hand.

Regression analysis was also preformed for varieties combined as types (example: Trison + Plainsman V = early maturing type) and for each type

combined with the standard variety, Sage. These combinations were fitted to a two-independent variable cubic regression model ($Y = B_o + s + n + s \times s + n \times n + s \times n + s \times s \times n + s \times n \times n + s \times s \times s + n \times n \times n$) at each location and seeding date and to a one-independent variable quadratic regression model ($Y = B_o + d + d \times d$) in Manhattan over all seeding dates and treatments. F tests for equality of the resultant regression models were preformed as follows:

$$SS_{(model)}\text{Type} + SS_{(model)}\text{Sage} - SS_{(model)}\text{Combined Run(Type + Sage)} = \text{Equality SS}$$

$$df_{(model)}\text{Type} + df_{(model)}\text{Sage} - df_{(model)}\text{Combined Run} = \text{df Equality}$$

$$SS_{(error)}\text{Type} + SS_{(error)}\text{Sage} = \text{Error SS}$$

$$df_{(error)}\text{Type} + df_{(error)}\text{Sage} = \text{df Error}$$

$$\text{MS Equality} = \frac{\text{Equality SS}}{\text{df Equality}} \qquad \text{Error MS} = \frac{\text{Error SS}}{\text{df Error}}$$

$$F = \frac{\text{MS Equality}}{\text{Error MS}}$$

RESULTS

Hutchinson

Analysis of variance for grain yield, grain protein percentage and test weight at Hutchinson for 1976 and 1977 are shown in Table 1. Grain yield, grain protein percentage and test weight were significantly or highly significantly affected by variety and treatment. The interaction of variety by treatment was significant for protein percentage only.

Simple correlation coefficients for each variety at Hutchinson in 1976 and 1977 are given in Table 2. Yield increased as seeding rate increased for all varieties. Nitrogen rate and protein were not significantly correlated with yield. Yield increased as test weight increased for all varieties but Trison. Correlation between yield and tiller number was positive and highly significant for all varieties. Yield and 100-seed weight were highly significantly and positively correlated for Lancota, Trison, Plainsman V and Funk W-335.

Protein increased as nitrogen rate increased for all varieties in Hutchinson. Protein was not significantly correlated with either seeding rate or yield. Correlation between protein and test weight was highly significant and negative for Pioneer HR 915A and significant and negative for Lancota. Protein and tiller number were significantly correlated for Sage only. Protein increased eith significantly or highly significantly for all varieties as 100-seed weight decreased.

Test weight and seeding rate were either highly significantly and positively correlated or significantly and positively correlated for all varieties but Lancota in Hutchinson. Nitrogen rate and test weight were highly significantly and negatively correlated for Funk W-335 and Pioneer HR 915A and significantly and positively correlated for Trison and Lancota. As yield increased,

Table 1. Analysis of variance for grain yield, protein percentage and test weight for the normal seeding date at Hutchinson, Colby and Manhattan in 1976 and 1977.

Source of Variation	d.t.	Mean Squares: Yield Hutchinson	Yield Colby	Yield Manhattan+	Protein Hutchinson	Protein Colby	Protein Manhattan+	Test Weight Hutchinson	Test Weight Colby	Test Weight Manhattan+,‡
Varieties	2	2086080.84*	918378.27**	6127006.91**	20.54**	32.27**	36.04**	41.41**	46.40	175.84*
Error V	12	492386.90	61894.33	298438.26	0.81	2.49	1.50	5.48	20.58	39.04
Treatments	12	6554387.27**	5536870.57**	3562032.33**	9.72**	31.82**	17.74**	31.21**	75.33**	98.87
VXT	72	183794.57	56099.12	189114.90	0.32*	0.42	1.91	2.79	9.86	66.95
Error T	168	148668.91	58210.70	185283.40	0.22	0.47	1.77	2.32	8.82	61.56

*, ** Significant at the .05 and .01 levels, respectively

+ Normal seeding date only

‡ 1976 data only

Table 2. Simple correlation coefficients between yield components and plant characteristics for each variety at Hutchinson in 1976 and 1977.

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Sage			
Seeding rate		0.0	.6692	-.1259	.5530**	.6794**	.2556
Nitrogen rate			.0681	.7542**	-.1349	-.0701	-.3821**
Yield				-.1187	.8559**	.5739**	.5553**
Protein					-.2856	-.3166*	-.4993**
Test weight						.4862**	.7221**
Tiller number							.2839
100 seed weight							
				Trison			
Seeding rate		0.0	.8107**	-.0011	.3322*	.7322**	.5345**
Nitrogen rate			.0694	.6774**	-.3437*	.0378	-.4464**
Yield				-.0083	.1372	.6525**	.6261**
Protein					-.2391	-.0810	-.4669**
Test weight						.2845	.1629
Tiller number							.4182**
100 seed weight							

Table 2. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Lancota			
Seeding rate		0.0	.6252**	.0256	.1991	.7012**	.2841
Nitrogen rate			-.0027	.8401**	-.4069*	.0502	-.6837**
Yield				.0287	.4404**	.4253**	.2004
Protein					-.3768*	-.0198	-.6121**
Test weight						.2874	.5791**
Tiller number							-.0241
100 seed weight							
				Plainsman V			
Seeding rate		0.0	.7252**	-.0132	.5850**	.7037**	.6317**
Nitrogen rate			.2871	.7521**	-.2117	-.0200	-.3962*
Yield				.1953	.6169**	.6804**	.4756**
Protein					-.2762	-.0232	-.3266*
Test weight						.6350**	.7676**
Tiller number							.2034
100 seed weight							

Table 2. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Funk W-335			
Seeding rate		0.0	.6839**	-.0061	.5219**	.7119**	.5372**
Nitrogen rate			.1677	.8053**	-.4348**	-.0259	-.6269**
Yield				.1408	.6639**	.6488**	.5000**
Protein					-.3042	-.1746	-.5471**
Test weight						.5243**	.8202**
Tiller number							.5269**
100 seed weight							
				Pioneer HR915A			
Seeding rate		0.0	.7717**	-.1963	.3929*	.7708**	.1899
Nitrogen rate			-.0154	.7138**	-.4451**	.0754	-.7393**
Yield				-.2494	.6036**	.7494**	.3121
Protein					-.4888**	-.0153	-.7038**
Test weight						.5081**	.7379**
Tiller number							.1855
100 seed weight							

Table 2. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Prairie Valley 4450			
Seeding rate		0.0	.5593**	.2316	.5382**	.6480**	.4286**
Nitrogen rate			.1929	.6898**	-.2318	.0558	-.4959**
Yield				.1375	.6784**	.6978**	.3160
Protein					-.2110	.1334	-.3640*
Test weight						.5378**	.6307**
Tiller number							.4140**
100 seed weight							

+ 1976 data only

*, ** Significant at the 0.05 and 0.01 levels, respectively

test weight increased highly significantly for all varieties but Trison. Test weight was highly significantly and negatively correlated with protein for Pioneer HR 915A and significantly and negatively correlated for Lancota. Test weight and 100-seed weight were highly significantly and positively correlated for all varieties but Trison and Plainsman V. All varieties but Trison and Lancota showed a positive and highly significant correlation between test weight and tiller number.

No differences in correlations were attributable to plant type in Hutchinson.

Response of grain yield, grain protein percentage and test weight to seeding and nitrogen rates in Hutchinson are shown for each variety in Figures 1, 2 and 3, respectively. Generally, yield increased from the low through the medium seeding rates while nitrogen rate had no marked effect on yield. Protein percentage increased with increased nitrogen rate for all varieties except Prairie Valley 4450 and Trison, which had high protein percentage at most nitrogen levels. Seeding rate had little effect on protein percentage for most varieties except Prairie Valley 4450, which appeared to have higher protein percentage at higher seeding rates. Test weight of all varieties was high at all nitrogen rates and at medium seeding rates. Test weight was low at the lowest seeding rates, especially in combination with high nitrogen rates.

Colby

Analysis of variance for grain yield, grain protein percentage and test weight at Colby for 1976 and 1977 are shown in Table 1. Grain yield and protein percentage were highly significantly affected by variety and treatment. However, only treatment highly significantly affected test weight. The interaction of variety by treatment was not significant in any case.

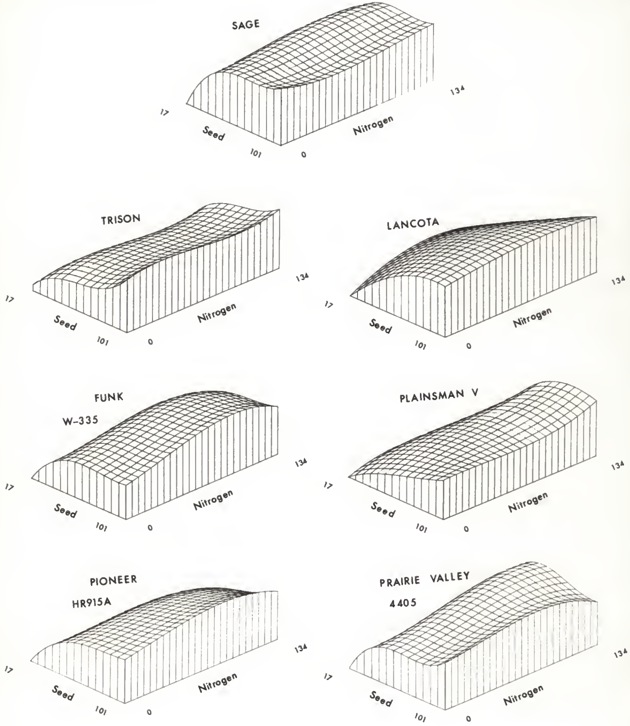

Figure 1. Seeding rate and nitrogen rate effects on grain yield of seven wheat varieties in Hutchinson during 1976 and 1977.

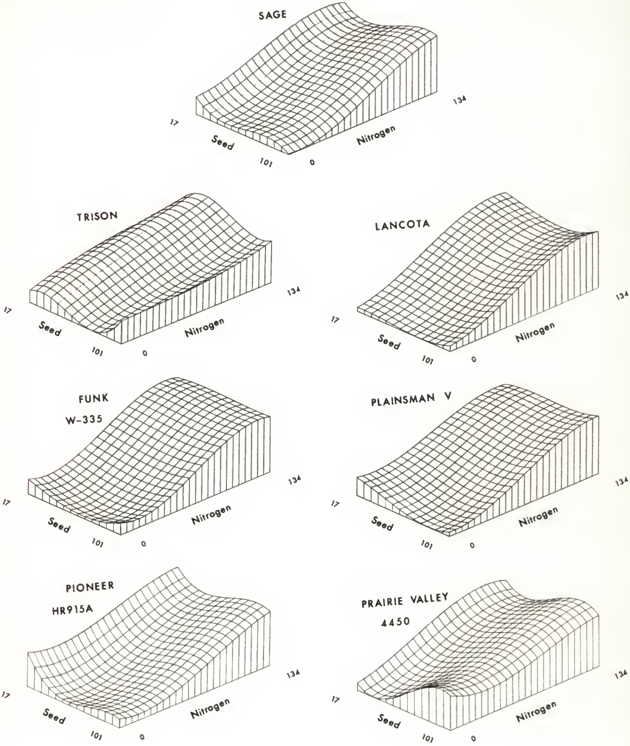

Figure 2. Seeding rate and nitrogen rate effects on grain protein concentration of seven wheat varieties in Hutchinson during 1976 and 1977.

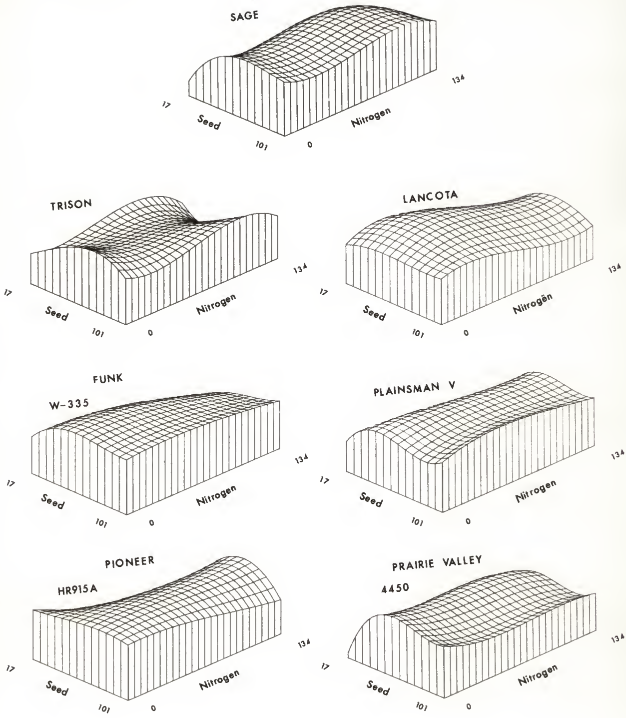

Figure 3. Seeding rate and nitrogen rate effects on test weight of seven wheat varieties in Hutchinson during 1976 and 1977.

Simple correlation coefficients for each variety at Colby for 1976 and 1977 are given in Table 3. Yield increased highly significantly as seeding rate increased for all varieties. Yield was not significantly correlated with nitrogen rate or protein. However, correlation between yield and test weight was highly significant and positive for all varieties except Prairie Valley 4450. Yield increased highly significantly as tiller number increased. Yield and 100-seed weight were positively and highly significantly correlated for Trison, Plainsman V and Funk W-335 only.

Protein was not significantly correlated with seeding rate, but was highly significantly and positively correlated with nitrogen rate for all varieties in Colby. Yield and protein were not significantly correlated. Correlation between protein and test weight was highly significantly or significantly negative for all varieties except Prairie Valley 4450. As 100-seed weight decreased, protein increased for all varieties.

Test weight and seeding rate were either significantly or high significantly and positively correlated for all varieties in Colby except Funk W-335 and Prairie Valley 4450. Test weight and nitrogen rate were highly significantly and negatively correlated for all varieties except Plainsman V and Prairie Valley 4450. Yield increased as test weight increased for all varieties but Prairie Valley 4450. Correlation between test weight and protein was negative, and either highly significant or significant, for all varieties except Prairie Valley 4450.

There were no differences in correlations attributable to plant type in Colby.

Response of grain yield, protein percentage and test weight to seeding and nitrogen rates for each variety at Colby are shown in Figures 4, 5 and 6, respectively.

Table 3. Simple correlation coefficients between yield components and plant characteristics for each variety at Colby in 1976 and 1977.

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Sage			
Seeding rate		0.0	.9050**	-.1506	.6582**	.6639**	.1742
Nitrogen rate			.0814	.8004**	-.4123**	.0690	-.4941**
Yield				-.1103	.6458**	.8224**	.1857
Protein					-.6236**	-.0876	-.6045**
Test weight						.1987	.5586**
Tiller number							.3160
100 seed weight							
				Trison			
Seeding rate		0.0	.8806**	-.1859	.6115**	.7841**	.4320**
Nitrogen rate			.0221	.8710**	-.4347**	.0132	-.5904**
Yield				-.2055	.6812**	.7733**	.5995**
Protein					-.5349**	-.0352	-.7910**
Test weight						.5329**	.7507**
Tiller number							.6315**
100 seed weight							

Table 3. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Lancota			
Seeding rate		0.0	.6134**	-.0559	.4921**	.7440**	.2253
Nitrogen rate			.1122	.7810**	-.6286**	.0913	-.5591**
Yield				-.1002	.5158**	.6200**	.3151
Protein					-.7779**	.0581	-.8120**
Test weight						.4628**	.7957**
100 seed weight							.6262**
				Plainsman V			
Seeding rate		0.0	.7634**	-.1484	.6374**	.7810**	.6582**
Nitrogen rate			.1872	.7459**	-.2770	.1437	-.5024**
Yield				.0302	.4854**	.7656**	.4887**
Protein					-.3223*	-.0812	-.5826**
Test weight						.4994**	.6785**
100 seed weight							.7379**

Table 3. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
				Funk W-335			
Seeding rate		0.0	.8786**	-.0623	.2896	.7726**	.3179*
Nitrogen rate			.0273	.8383**	-.5403**	.0725	-.6428**
Yield				-.0805	.4831**	.8000**	.4769**
Protein					-.6046**	-.1969	-.7693**
Test weight						.1198	.8204**
Tiller number							.5216**
100 seed weight							
				Pioneer HR915A			
Seeding rate		0.0	.8268**	-.0632	.3923*	.6691	-.0128
Nitrogen rate			.0752	.8832**	-.6946**	.2812	-.8059**
Yield				-.0545	.4561**	.7533**	.0832
Protein					-.8321**	-.1061	-.8975**
Test weight						.3633*	.7996**
Tiller number							.5129**
100 seed weight							

Table 3. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test Weight	Tiller+ Number	100 Seed Weight
			Prairie Valley 4450				
Seeding rate		0.0	.8240**	-.1783	.0807	.6595**	.0988
Nitrogen rate			.0852	.7785**	-.1004	.2026	-.5999**
Yield				-.1818	-.0272	.8262**	.2447
Protein					.0223	-.2223	-.7640**
Test weight						-.0028	.1555
Tiller number							.6534**
100 seed weight							

+ 1977 data only

*, ** Significant at the 0.05 and 0.01 levels, respectively

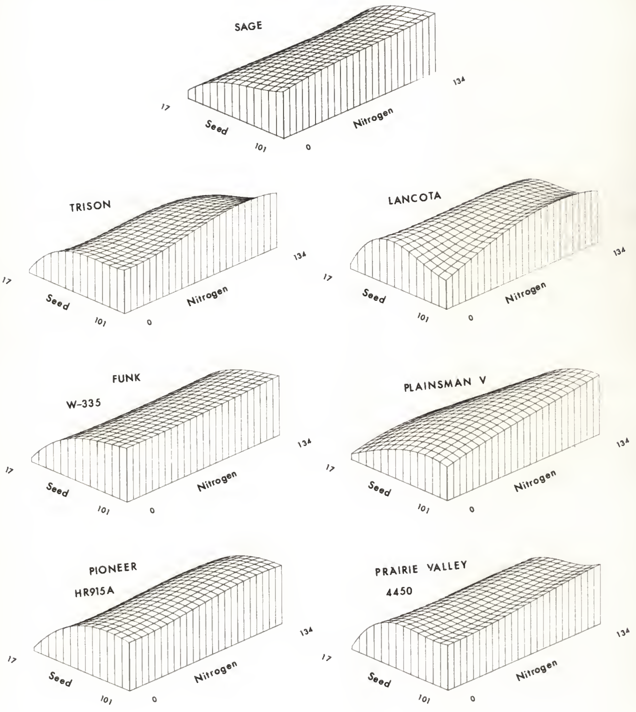

Figure 4. Seeding rate and nitrogen rate effects on grain yield of seven wheat varieties in Colby during 1976 and 1977.

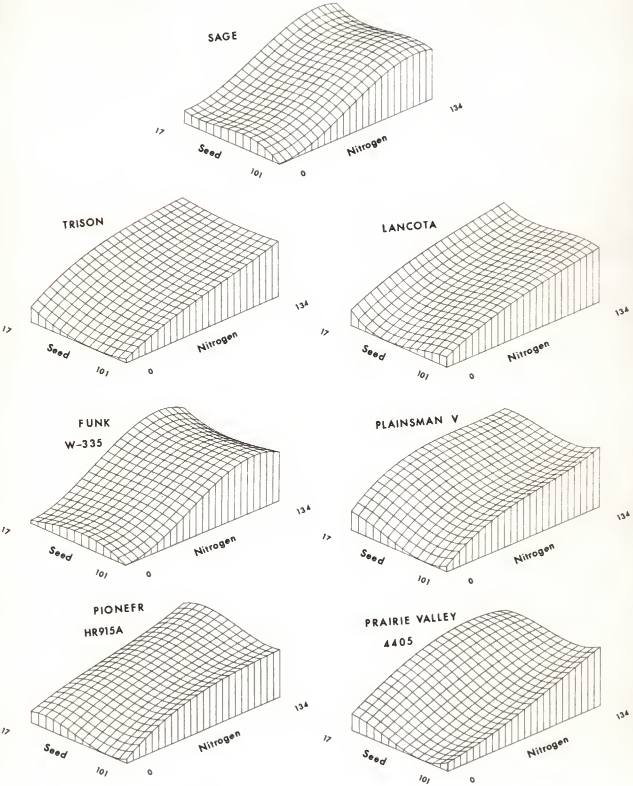

Figure 5. Seeding rate and nitrogen rate effects on grain protein concentration of seven wheat varieties in Colby during 1976 and 1977.

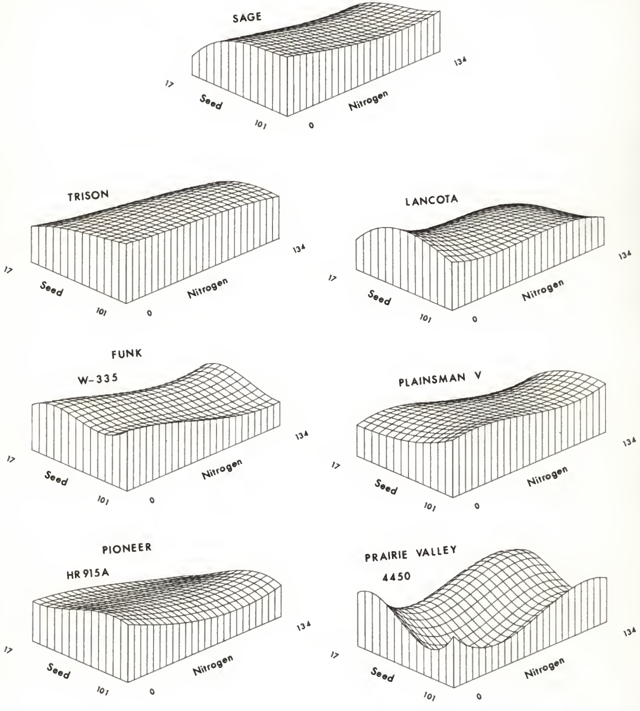

Figure 6. Seeding rate and nitrogen rate effects on test weight of seven wheat varieties in Colby during 1976 and 1977.

Generally, yield increased with increased nitrogen rate and from the low through the medium seeding rates. Yield was high with medium seeding rates in combination with high nitrogen rates. Protein percentage increased with increased nitrogen rate for all varieties. The lowest seeding rate also resulted in high protein percentage; the highest protein percentages were at low seeding rates with high nitrogen rates. Test weight was high for all varieties at all seeding rate and nitrogen rate combinations.

Manhattan

Normal Seeding Date

Analysis of variance for grain yield, grain protein percentage and test weight at Manhattan for 1976 and 1977 for the normal seeding date is shown in Table 1. Variety and treatment highly significantly affected grain yield and protein percentage. The effect of variety on test weight was significant while the effect of treatment and the interaction of variety by treatment were not significant.

Simple correlation coefficients for each variety at Manhattan at the normal seeding date for 1976 and 1977 are given in Table 4. Yield and seeding rate were highly significantly and positively correlated for all varieties. Yield and nitrogen rate were not significantly correlated, but yield and protein percentage were highly significantly and negatively correlated for Funk W-335 only. Correlation between yield and test weight was either highly significant or significant and positive for all varieties. Yield highly significantly increased as tiller number increased for all varieties except Lancota and Prairie Valley 4450. Yield was highly significantly or significantly positively correlated with 100-seed weight for all varieties. Yield decreased as flowering was delayed for all varieties but Plainsman V and Pioneer HR 915A. Yield and plant height were highly significantly and

Table 4. Simple correlation coefficients between yield components and plant characteristics for each variety at Manhattan for normal seeding date in 1976 and 1977.

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower- ing Date	Plant Height	Weeds
					Sage					
Seeding rate		0.0	.7372**	-.4210**	.4692**	.6405**	.4135**	-.5014**	.2074	-.8592**
Nitrogen rate			.1541	.6228**	-.3233*	.2262	-.2081	-.0152	.0951	.0174
Yield				-.2330	.6012**	.7021**	.3444*	-.4810**	.2490	-.7588**
Protein					-.4560**	-.2144	-.5824**	.4564**	-.1249	.4654**
Test weight						.5123**	.3158	-.3504*	.0990	-.6172**
Tiller number							.3605*	-.5352**	.2187	-.6548**
100 seed weight								-.5626**	.1450	-.4317**
Flowering date									.0458	.5625**
Plant height										-.6548**
Weeds										
					Trison					
Seeding rate		0.0	.6610**	-.3624*	.0722	.7116**	.5410**	-.4668**	.2193	-.7657**
Nitrogen rate			.1995	.6002**	-.0367	.1811	-.2600	.0660	.0671	.0928
Yield				-.2936	7388**	.7779**	.6267**	-.4517**	.3062	-.7375**
Protein					-.3879*	-.1099	-.6418**	.2145	.0129	.4301**
Test weight						.2300	.7121**	-.3350	.2691	-.3381*
Tiller number							.4456**	-.4199**	.3160	-.7837**
100 seed weight								-.1932	.1988	-.5953**
Flowering date									-.2383	.3955*
Plant height										-.4217**
Weeds										

Table 4. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower- ing Date	Plant Height	Weeds
					Lancota					
Seeding rate		0.0	.6064**	-.1464	.3057	.5000**	.4352**	-.4630**	.2323	-.7631**
Nitrogen rate			.1264	.5429**	-.2572	.3484*	-.0832	.3524*	.0342	.0893
Yield				-.1221	.5792**	.2991	.6280**	-.5075**	.5483**	-.5357**
Protein					-.4704**	.0750	-.2798	.3817*	-.0809	.2305
Test weight						-.1355	.6481**	-.2833	.2550	-.2177
Tiller number							.1512	-.0932	.1698	-.5546**
100 seed weight								-.5672**	.3598*	-.4780**
Flowering date									-.2707	.4998**
Plant height										-.2657
Weeds										
					Plainsman V					
Seeding rate		0.0	.6035**	-.0666	.2664	.6960**	.3728*	-.3980*	-.2322	-.7190**
Nitrogen rate			.0268	.6034**	-.1863	.2977	-.3600*	.3116	.0093	.2595
Yield				-.3148	.3345*	.5033**	.5404**	-.2426	.5165**	-.6634**
Protein					-.3410*	.0380	-.5078**	.1116	-.1208	.5054**
Test weight						.0783	.6238**	-.1766	-.0904	-.3696*
Tiller number							.1089	-.1244	.2604	-.6588**
100 seed weight								-.2450	.0830	-.5737**
Flowering date									-.1935	.3156
Plant height										-.2586
Weeds										

Table 4. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower- ing Date	Plant Height	Weeds
					Funk W-335					
Seeding rate		0.0	.7257**	-.4285**	.3884*	.5790**	.5552	-.7122**	.2641	-.8731**
Nitrogen rate			-.0731	.5842**	-.4326**	.3704*	-.4023	.3518*	.1233	-.0420
Yield				-.4676**	.5435**	.6093**	.7721**	-.7406**	.3094	-.7871**
Protein					-.6043**	-.0831	-.7360**	.6045**	.0237	.3918*
Test weight						-.0635	.7042**	-.5097**	-.1701	-.1839
Tiller number							.1714	-.3484*	.4022*	-.5591**
100 seed weight								-.6716**	.1309	-.6219**
Flowering date									-.2286	.7611**
Plant height										-.4186**
Weeds										
					Pioneer HR915A					
Seeding rate		0.0	.6764**	-.3741*	.3906*	.6082**	.4509**	-.4330**	.4739**	-.7744**
Nitrogen rate			.2472	.6078**	-.2638	.4070*	-.2122	.3362*	.1164	-.0060
Yield				-.3086	.4577**	.7815**	.6223**	-.2981	.6599**	-.8185**
Protein					-.5397**	-.08046	-.7089**	.3800*	-.2853	.4304**
Test weight						.2404	.6321**	-.2716	-.0872	-.5146**
Tiller number							.3328*	-.2613	.4225**	-.6826**
100 seed weight								-.3665*	.4861**	-.6725**
Flowering date									-.4018*	.4663**
Plant height										-.5541**
Weeds										

Table 4. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower- ing Date	Plant Height	Weeds
					Prairie Valley 4450					
Seeding rate		0.0	.5211**	-.3136	-.0741	.5355**	.5824**	-.4663**	.2246	-.7507**
Nitrogen rate			.3835*	.5352**	-.0939	-.0495	-.2593	.0555	.3102	.0711
Yield				-.1893	.3817*	.1897	.4073*	-.4549**	.4264**	-.5521**
Protein					-.3985*	-.1612	-.4805**	.4404**	-.0250	.4494**
Test weight						.0193	.6847**	-.0963	.5170**	-.1350
Tiller number							.4416**	-.1713	-.1264	-.3781*
100 seed weight								-.6289**	.3637*	-.5591**
Flowering date									-.3838*	.4790**
Plant height										-.3574*
Weeds										

+ 1976 data only

*, ** Significant at the 0.05 and 0.01 levels, respectively

positively correlated for Lancota, Plainsman V, Pioneer HR 915A and Prairie Valley 4450. Yield decreased as weed infestation increased for all varieties.

Protein and seeding rate were highly significantly and negatively correlated for Sage and Funk W-335 and significantly and negatively correlated for Lancota and Pioneer HR 915A. As nitrogen rate increased, protein increased for all varieties in Manhattan at the normal seeding date. Yield and protein were highly significantly and negatively correlated for Funk W-335 only. Correlation between protein and test weight was negative and either highly significant or significant for all varieties except Prairie Valley 4450. Protein increased highly significantly as 100-seed weight decreased for all varieties except Lancota. Protein increased as flowering date was delayed highly significantly for Sage, Funk W-335 and Prairie Valley 4450 and significantly for Lancota and Pioneer HR 915A. Protein and weed cover were either highly significantly and positively or significantly and positively correlated for all varieties except Lancota.

Test weight and seeding rate were highly significantly and positively correlated for Sage only at Manhattan at the normal seeding date. Test weight and nitrogen rate were highly significantly and negatively correlated for Sage and significantly and negatively correlated for Funk W-335. Test weight increased highly significantly or significantly for all varieties as yield increased. While test weight increased, protein percentage decreased highly significantly for all varieties. Test weight and tiller number were highly significantly and positively correlated for Sage only. Correlation between test weight and 100-seed weight was positive and highly significant for all varieties except Sage. Test weight and flowering date were highly significantly and negatively correlated for Funk W-335 only but significantly and negatively correlated for Sage and Trison. Test weights decreased highly significantly for Pioneer HR 915A and significantly for Trison and Plainsman V as weeds increased.

Weed infestation increased highly significantly as seeding rate decreased for all varieties in Manhattan at the normal seeding date. Nitrogen rate was not significantly correlated with weeds. Yield decreased highly significantly for all varieties but Lancota as weeds increased. Weed infestation and test weight were either highly significantly or significantly and negatively correlated for all varieties except Lancota, Funk W-335 and Prairie Valley 4450. Weeds and tiller number were highly significantly and negatively correlated for all varieties but Prairie Valley 4450, for which they were significantly and negatively correlated. As weeds increased, 100-seed weight highly significantly decreased for all varieties. Flowering date and weed infestation were highly significantly and positively correlated for all varieties but Plainsman V. Weeds and plant height were highly significantly and positively correlated for all varieties but Lancota, Funk W-335 and Prairie Valley 4450.

The early maturing varieties, Trison and Plainsman V, showed characteristic negative correlations between protein percentage and test weight and between test weight and weeds that were attributable to plant type. They also showed a distinctive lack of significant correlation between plant height and weeds that could be due to plant type.

Response of grain yield, grain protein percentage and test weight to seeding and nitrogen rates for all varieties at Manhattan for the normal seeding date are given in Figures 7, 8 and 9, respectively. Generally, yield increased with increased nitrogen and increased seeding rate for all varieties. High nitrogen rate combined with high seeding rates resulted in high yield. Protein percentage increased with increased nitrogen rate. Low seeding rates also resulted in high protein percentage. Test weight was high for all varieties at all nitrogen rates and most seeding rates.

Treatments did not affect test weight in Manhattan at the normal seeding date.

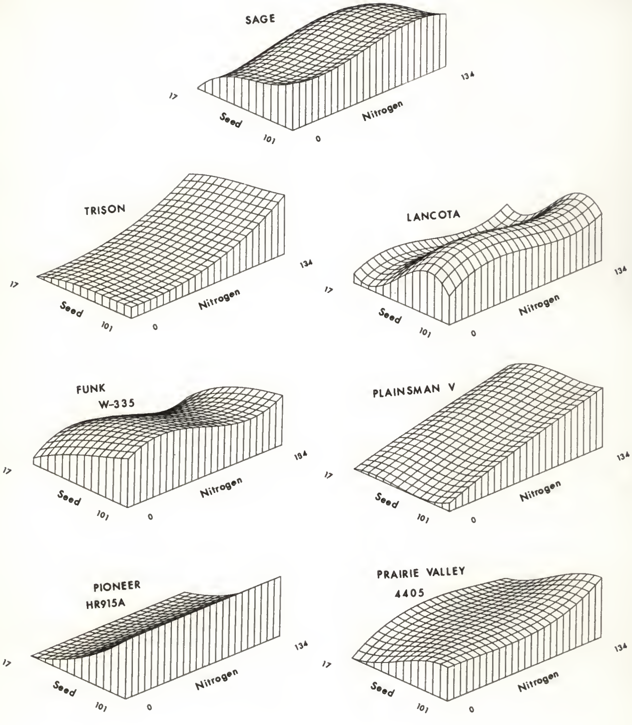

Figure 7. Seeding rate and nitrogen rate effects on grain yield of seven wheat varieties seeded at a normal date in Manhattan during 1976 and 1977.

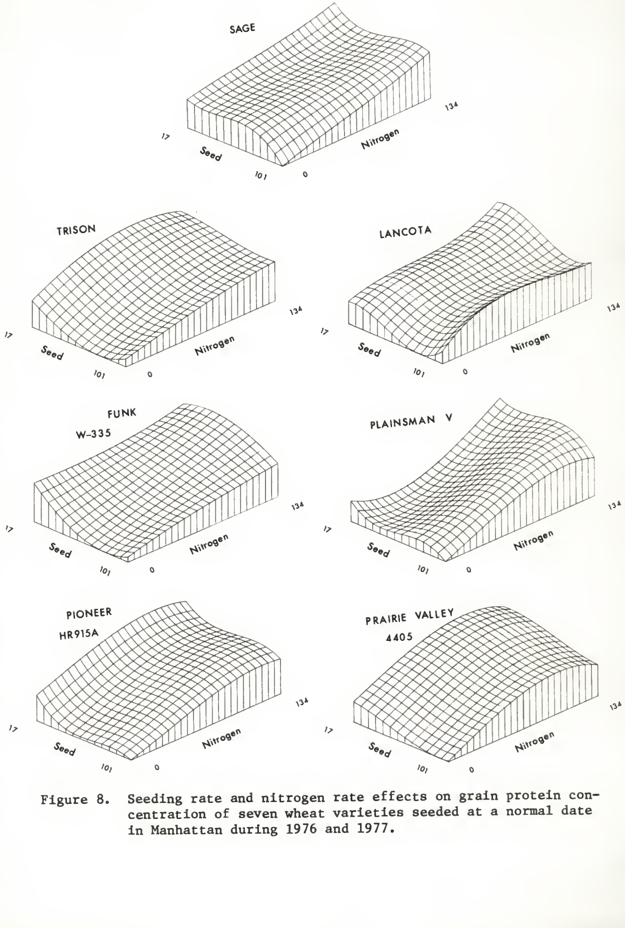

Figure 8. Seeding rate and nitrogen rate effects on grain protein concentration of seven wheat varieties seeded at a normal date in Manhattan during 1976 and 1977.

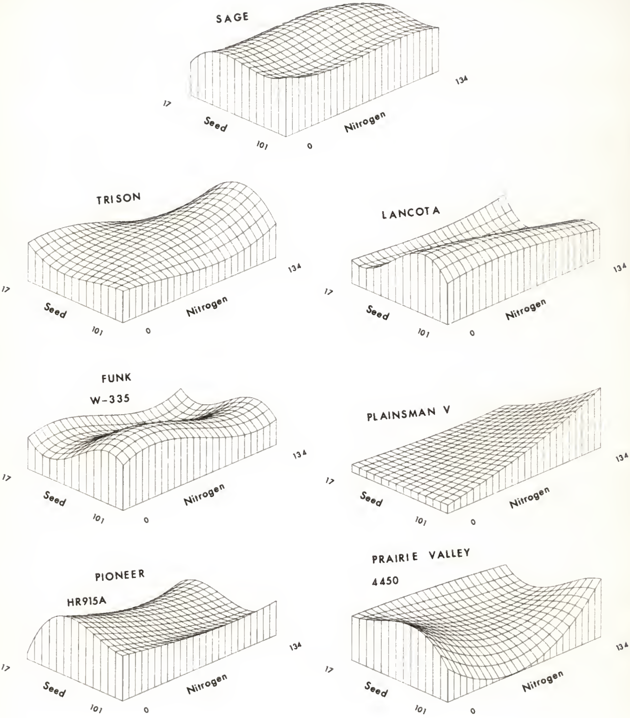

Figure 9. Seeding rate and nitrogen rate effects on test weight of seven wheat varieties seeded at a normal date in Manhattan during 1976.

Analysis of variance for grain yield, grain protein percentage and test weight for all three locations at the normal seeding date in 1976 and 1977 is shown in Table 5. Grain yield and protein percentage were highly significantly affected by location, variety and treatments. Interactions of location by variety and location by treatment were also highly significant. Test weight was significantly affected by variety and treatment. The variety by treatment and location by variety by treatment interactions were not significant.

Grain yield, protein percentage and test weight means for each location over all varieties, treatments and years are given in Table 6. Yield was significantly higher at Hutchinson than at Colby and Manhattan and was significantly higher at Colby than at Manhattan. Protein percentage was significantly higher in Manhattan than in Hutchinson and Colby and test weight was significantly higher in Hutchinson than in Manhattan.

Early Seeding Date

Analysis of variance for grain yield, grain protein percentage and test weight at Manhattan at the early seeding date for 1976 and 1977 is shown in Table 7. Grain yield and grain protein percentage were highly significantly affected by variety and treatment. Test weight was highly significantly affected by treatment only. The interaction of variety by treatment was not significant in any case.

Simple correlation coefficients for each variety in Manhattan at the early seeding date for 1976 and 1977 are given in Table 8. Yield and seeding rate were not significantly correlated. Yield and nitrogen rate were highly significantly and positively correlated for Plainsman V and Pioneer HR 915A and significantly and positively correlated for Sage and Trison. Yield and protein were not significantly correlated. Correlation between yield and test weight was significantly or highly significantly positive for all varieties except

Table 5. Analysis of variance for grain yield, protein percentage and test weight for the normal seeding date at all three locations in 1976 and 1977.

Source of Variation	d.f.	Mean Squares Yield	Protein	Test Weight+
Location	2	190871766.75**	271.90**	145090.55*
Error L	4	303328.54	8.83	20174.88
Variety	6	6660808.65**	79.89**	35565.87**
LXV	12	1235328.69**	4.48**	12843.33
Error V	36	284239.83	1.60	7619.96
Treatment	12	15103822.82**	51.36**	20392.75**
LXT	24	274733.67**	3.96**	8153.84
VXT	72	155369.32	0.80	6302.49
LXVXT	144	136819.63	0.92	5702.37
Error T	504	130721.00	0.82	5679.83

*, ** Significant at the .05 and .01 levels, respectively

+ 1976 data only

Table 6. Mean grain yield, protein percentage and test weight over all treatments, varieties and years.

Dates or Location	Yield	Protein	Test weight+
	-kg/ha-	-%-	-kg/hl-
	Dates at Manhattan		
Early	1635	14.7	80.6
Normal	1573	15.8	84.5
Late	848	16.8	66.1
L.S.D. .05	262	0.4	12.8
	Locations Normal Seeding Date		
Hutchinson	3220	14.4	89.1
Colby	2147	13.9	86.9
Manhattan	1573	15.8	84.5
L.S.D. .05	131	0.7	3.4

+ 1976 data only

Table 7. Analysis of variance for grain yield, protein percentage and test weight at Manhattan at the late and early seeding dates in 1976 and 1977.

		Mean Squares					
		Yield		Protein		Test Weight+	
Source of Variation	d.f.	Manhattan Early	Manhattan Late	Manhattan Early	Manhattan Late	Manhattan Early	Manhattan Late
Varieties	6	3135848.16**	987334.76**	10.95**	14.90**	51.96	126.53*
Error (V)	12	359813.95	195959.78	0.90	2.06	29.36	26.42
Treatments	12	948484.77**	2137010.72**	16.08**	20.66**	29.50**	282.08**
VXT	72	237057.70	78841.75	0.78	0.74	10.32	15.26*
Error (T)	168	212833.43	72248.53	0.74	0.63	8.01	10.92

*, ** Significant at the .05 and .01 levels, respectively

+ 1976 data only

Table 8. Simple correlation coefficients between yield components and plant characteristics for each variety at Manhattan for early seeded wheat in 1976 and 1977.

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Sage					
Seeding rate		0.0	.1038	.0125	-.0176	.4511**	.2380	-.0615	.0120	-.2531
Nitrogen rate			.3268*	.5661**	-.0213	.1242	.1138	.1211	-.1201	-.1964
Yield				-.1723	.4304**	.4070*	.5248**	-.2493	.4541**	-.4081**
Protein					-.2003	-.2142	-.5346**	.2932	-.4308**	.2812
Test weight						.0776	.3753*	-.0574	.2985	-.1273
Tiller number							.4762**	-.2196	.5349**	-.6118**
100 seed weight								-.3264*	.2566	-.6070**
Flowering date									-.3017	.3568*
Plant height										-.4446**
Weeds										
					Trison					
Seeding rate		0.0	.0694	-.1954	-.0317	.3741*	.3425*	-.4469**	.2322	-.1889
Nitrogen rate			.3733*	.6047**	-.1139	.2515	-.1187	.2027	.1491	.0686
Yield				-.0631	.5338**	.3754*	.5588**	-.2824	.5775**	-.6211**
Protein					-.4448**	.0560	-.4947**	.3547*	-.0298	.3463*
Test weight						-.0814	.7092**	.1079	.2522	-.6463**
Tiller number							.3938*	-.2484	.4050*	-.3980*
100 seed weight								-.4052*	.2514	-.6607**
Flowering date									-.1405	.4835**
Plant height										-.4263**
Weeds										

Table 8. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Lancota					
Seeding		0.0	-.0229	.0635	.0288	.1356	.1280	-.1138	.0087	-.1962
Nitrogen rate			.0344	.5996**	-.5326**	.2051	-.4060*	.3418*	.2566	-.0742
Yield				-.2477	.4985**	.1970	.5918**	-.0321	.4188**	-.5268**
Protein					-.6747**	.2125	-.5830**	.2298	.1682	.0038
Test weight						-.0520	.7259**	.2597	.0266	-.6117
Tiller number							.0463	-.4196**	.6311**	-.4568**
100 seed weight								-.2478	.0725	-.3046
Flowering date									-.1032	.2873
Plant height										-.4026*
Weeds										
					Plainsman V					
Seeding rate		0.0	-.1622	.3744*	-.2660	.3753*	-.0572	-.3380*	-.1406	-.1624
Nitrogen rate			.4212**	.6070**	-.1976	.4165**	-.04034	.3321*	.2926	.0462
Yield				.1228	.2337	.5294**	.5312**	-.1599	.3027	-.4508**
Protein					-.2813	.3934*	-.3025	.1222	.1061	.0199
Test weight						-.2392	.2727	-.1634	-.3124	-.3382*
Tiller number							.2313	-.2163	.2714	-.3775*
100 seed weight								-.0450	.0594	-.4512**
Flowering date									.1024	.2554
Plant height										-.1862
Weeds										

Table 8. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Funk W-335					
Seeding rate		0.0	.0677	-.0214	.0878	.2903	-.0923	.0302	-.0336	-.4742**
Nitrogen rate			.1650	.7524**	-.6452**	.2760	-.4683**	.2162	.1756	.0244
Yield				-.2090	.3680*	.4102**	.3309*	-.1294	.5065**	-.6908**
Protein					-.6705**	-.0073	-.5947**	.4049*	.0598	.3769*
Test weight						-.0592	.6727**	.1026	-.1481	-.3677*
Tiller number							.1497	.2205	.2270	-.5003**
100 seed weight								-.3131	-.0167	-.2644
Flowering date									.0834	.2577
Plant height										-.3860*
Weeds										
					Pioneer HR915A					
Seeding rate		0.0	.0505	-.0666	.0358	.4079*	-.0400	.1049	-.0157	-.2554
Nitrogen rate			.4412**	.8106**	-.3279	.2758	-.2163	.3744*	.2222	-.1905
Yield				.0511	.5264**	.3421*	.5880**	.0216	.6088**	-.5142**
Protein					-.3605*	.0728	-.5204**	.3106	-.0542	.0967
Test weight						.1628	.8142**	.1294	.0884	-.1464
Tiller number							.1950	.1248	.6326**	-.5833**
100 seed weight								-.1551	.4849**	-.3925*
Flowering date									-.0536	.0603
Plant height										-.3805*
Weeds										

Table 8. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Prairie Valley 4450					
Seeding rate		0.0	.2615	.0039	.2036	.4308**	.3528*	-.1619	.2116	-.6284**
Nitrogen rate			.2920	.7866**	-.2323	.6027**	.0824	.1476	.1655	-.1795
Yield				-.0324	.4478**	.2615	.6417**	.1062	.5526**	-.4213**
Protein					-.2709**	.4872**	-.2575	-.0309	.0813	-.0387
Test weight						.0159	.7890**	.4817**	.3028	-.5638**
Tiller number							.4107**	-.0368	.3411*	-.5668**
100 seed weight								.0038	.5187**	-.4468**
Flowering date									-.0931	.1184
Plant height										-.5686**
Weeds										

+ 1976 data only

*, ** Significant at the 0.05 and 0.01 levels, respectively

Plainsman V. Yield was highly significantly positively correlated with tiller number for Plainsman V and Funk W-335 and significantly positively correlated for Sage, Trison and Pioneer HR 915A. Yield and test weight were significantly and positively correlated for Funk W-335 and highly significantly and positively correlated for the other varieties. Yield increased as plant height increased for all varieties except Plainsman V and Funk W-335. Yield highly significantly decreased as weed infestation increased.

Protein and seeding rate were significantly and positively correlated for Plainsman V only. Protein increased as nitrogen rate increased in Manhattan at the early seeding date. Yield and protein were not significantly correlated, while protein and test weight were highly significantly negatively correlated for Trison, Lancota, Funk W-335 and Prairie Valley 4450, and significantly negatively correlated for Pioneer HR 915A. Protein and tiller number were highly significantly positively correlated for Plainsman V. As 100-seed weight decreased, protein highly significantly increased for all varieties but Plainsman V and Prairie Valley 4450. Trison and Funk W-335 showed significant positive correlation between flowering date and protein.

Test weight and seeding rate were not significantly correlated for any variety in Manhattan at the early seeding date. Nitrogen rate and test weight were negatively and highly significantly correlated for Lancota and Funk W-335 and negatively and significantly correlated for Pioneer HR 915A. Test weight increased with increased yield for all varieties but Plainsman V. Test weight increased as 100-seed weight increased for all varieties but Plainsman V. Flowering date and test weight were highly significantly and positively correlated for Pioneer HR 915A only. Weeds and test weight were highly significantly and negatively correlated for Trison, Lancota and Prairie Valley 4450 and significantly and negatively correlated for Plainsman V and Funk W-335.

Weed infestation and seeding rate were highly significantly negatively correlated for Funk W-335 and Prairie Valley 4450 only in Manhattan at the early seeding date. As weeds increased, yields decreased for all varieties. Only Trison and Funk W-335 showed a significant and negative correlation between weeds and protein. Weeds and test weight were highly significantly and negatively correlated for Sage, Lancota and Prairie Valley 4450 and significantly and negatively correlated for Plainsman V and Funk W-335. Correlation between weeds and tiller number was negative and either highly significant or significant for all varieties. Weeds and 100-seed weight were highly significantly and negatively correlated for Sage, Lancota, Plainsman V and Prairie Valley 4450 and significantly and negatively correlated for Pioneer HR 915A. Flowering date was highly significantly and positively correlated with weeds for Trison and significantly and positively correlated with weeds for Sage. As plant height increased, weeds decreased for all varieties but Plainsman V.

The semidwarf varieties, Funk W-335 and Plainsman V, showed distinctive correlations between yield and tiller number and between test weight and weed infestation that were attributable to their plant type. The early maturing varieties, Trison and Plainsman V, showed characteristic correlation between weeds and tiller number that were attributable to their plant type.

Response of grain yield, grain protein percentage and test weight to seeding and nitrogen rates at Manhattan at the early seeding date are shown for each variety in Figures 10, 11 and 12, respectively. Generally, yield increased nitrogen rate. High yields of most varieties occurred at the medium seeding rates. Protein percentage also increased with increased nitrogen rate. Most seeding rates, especially the low rate, resulted in high protein percentage. Generally, test weight increased with increased nitrogen rate for all varieties except Funk W-335 and Plainsman V when it was combined with high seeding rates. Test weight was high at most seeding rates, especially when nitrogen rate was high.

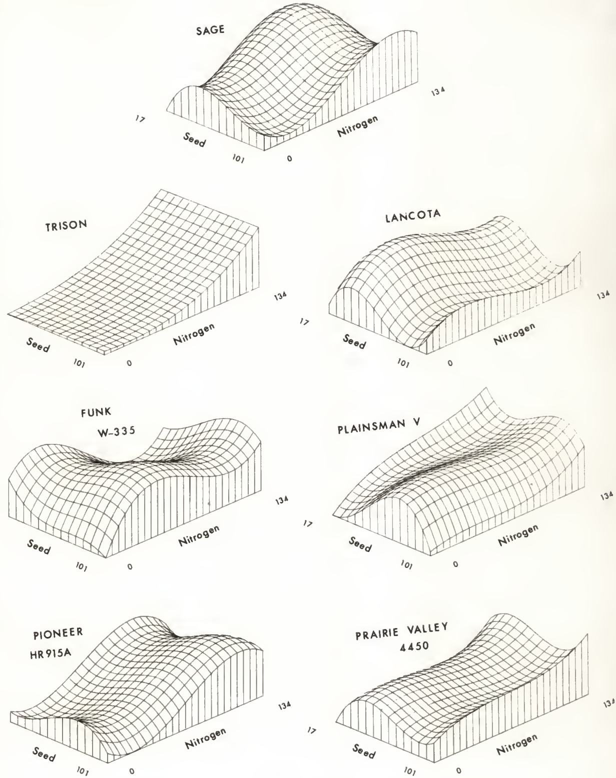

Figure 10. Seeding rate and nitrogen rate effects on grain yield of seven wheat varieties seeded at an early date in Manhattan during 1976 and 1977.

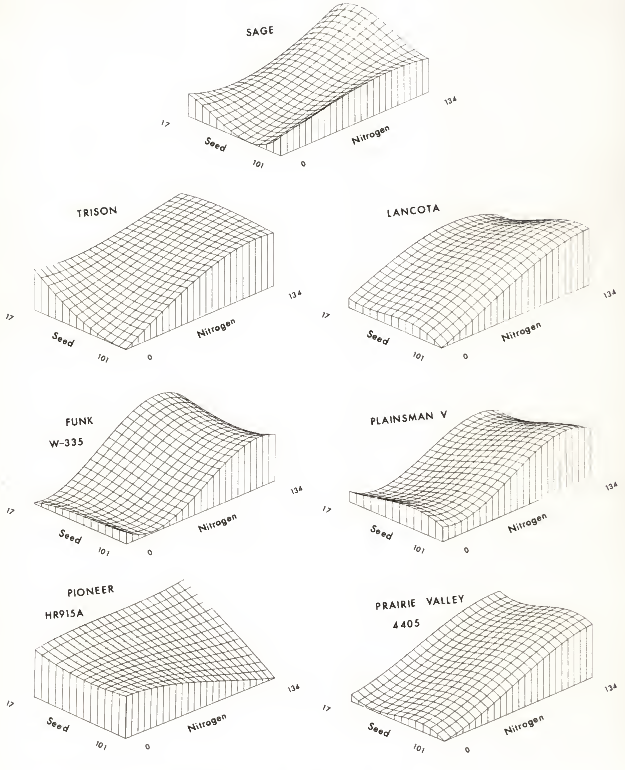

Figure 11. Seeding rate and nitrogen rate effects on grain protein concentration of seven wheat varieties seeded at an early date in Manhattan during 1976 and 1977.

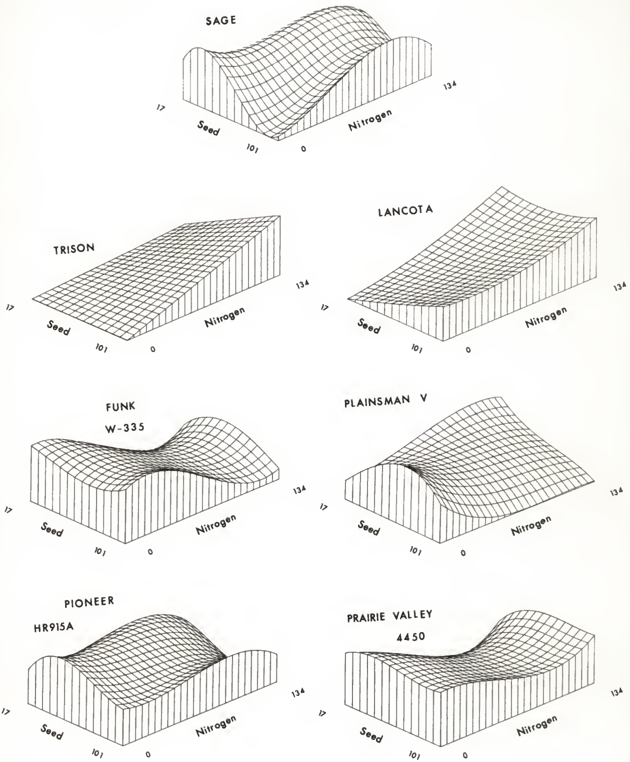

Figure 12. Seeding rate and nitrogen rate effects on test weight of seven wheat varieties seeded at an early date in Manhattan during 1976.

Late Seeding Date

Analysis of variance for grain yield, grain protein percentage and test weight for 1976 and 1977 at Manhattan at the late seeding date is shown in Table 7. Grain yield and protein percentage were highly significantly affected by variety and treatment. Test weight was significantly affected by variety and highly significantly affected by treatment. The variety by treatment interaction was significant for test weight only.

Simple correlation coefficients for each variety at Manhattan at the late seeding date for 1976 and 1977 are given in Table 9. Yield increased as seeding rate increased for all varieties. Yield and nitrogen rate were not significantly correlated, while protein decreased as yield increased for all varieties. Yield increased as test weight and tiller number increased for all varieties. Yield and 100-seed weight were positively and highly significantly correlated for all varieties.

Protein percentage decreased as seeding rate increased for all varieties except Plainsman V and Prairie Valley 4450 at Manhattan at the late seeding date. Protein percentage increased highly significantly as nitrogen rate increased for all varieties and protein decreased as yield increased for all varieties. Correlation between protein and test weight was highly significantly negative for all varieties except Plainsman V. Protein and tiller number were highly significantly negatively correlated for Lancota, Plainsman V and Funk W-335 only. Protein percentage decreased as 100-seed weight increased for all varieties. Protein and flowering date were highly significantly positively correlated for Funk W-335 and Sage and significantly and positively correlated for Lancota and Plainsman V. Protein and plant height were highly significantly and negatively correlated for Funk W-335 and significantly and negatively correlated for Lancota only. Protein percentage increased for all varieties as weeds increased.

Table 9. Simple correlation coefficients between yield components and plant characteristics for each variety at Manhattan for late seeded wheat in 1976 and 1977.

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flowering Date	Plant Height	Weeds
					Sage					
Seeding rate		0.0	.7648**	-.3688*	.3943*	.7278**	.0967	-.3552*	.4970**	-.7149**
Nitrogen rate			-.0464	.6019**	-.2600	.2628	-.1467	.0508	.2891	-.0579
Yield				-.5594**	.5818**	.7408**	.2804	-.4589**	.6000**	-.7960**
Protein					-.5887**	-.2073	-.4574**	.1330	-.1414	.4240**
Test weight						.2538	.3036	.0706	.1838	-.4654**
Tiller number							-.0742	-.6787**	.8134**	-.7049**
100 seed weight								.2234	-.2098	-.2457
Flowering date									-.6620**	.4279*
Plant height										-.5059**
Weeds										
					Trison					
Seeding rate		0.0	.7923**	-.4624**	.4895**	.6538**	.7057**	-.5499**	.5334**	-.7419**
Nitrogen rate			-.0849	.6234**	-.2848	.0502	-.3416*	-.1940	.0304	.1194
Yield				-.4687**	.6491**	.7954**	.6609**	-.4228**	.7406**	-.7585**
Protein					-.6395**	-.2302	-.7848**	.0170	-.1712	.5372**
Test weight						.2838	.7929**	-.1094	.1841	-.7200**
Tiller number							.3955*	-.5945**	.7353**	-.5161**
100 seed weight								-.1945	.2710	-.6765**
Flowering date									-.4624**	.1814
Plant height										-.4494**
Weeds										

Table 9. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Lancota					
Seeding rate		0.0	.5856**	-.4201**	.4014*	.5383**	.4665**	-.3207*	.4135**	-.5822**
Nitrogen rate			-.0256	.5741**	.4942**	.2149	-.3988*	-.1054	.2764	.0881
Yield				-.5390**	.4946**	.6838**	.5103**	-.5780**	.6183**	-.7455**
Protein					-.6706**	-.4077*	-.4983**	.4039*	-.3675*	.5631**
Test weight						.2784	.6719**	-.3119	.0834	-.4705**
Tiller number							.1345	-.8037**	.8145**	-.7338**
100 seed weight								-.0289	.0754	-.4411**
Flowering date									-.6935**	.6063*
Plant height										-.6075**
Weeds										
					Plainsman V					
Seeding rate		0.0	.7166**	-.2947	.7234**	.6590**	.5439**	-.5119**	.4392**	-.7339**
Nitrogen rate			-.0137	.5379**	-.2573	.1839	-.3669*	.0964	0.0	.0386
Yield				-.4584**	.7234**	.8241**	.4905**	-.7710**	.7315**	-.8400**
Protein					-.5785**	-.2768	-.6264**	.3972*	-.2340	.4662**
Test weight						.5313**	.4947**	-.4650	.5241**	-.7612**
Ti-ler number							.4004*	-.6399**	.6164**	-.7319**
100 seed weight								-.3538*	.2467	-.5590**
Flowering date									.6523**	.6670**
Plant height										-.5876**
Weeds										

Table 9. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flower-ing Date	Plant Height	Weeds
					Funk W-335					
Seeding rate		0.0	.6900**	-.5890**	.6232**	.6310**	.5820**	-.4363**	.5849**	-.7932**
Nitrogen rate			-.1983	.5026**	-.3489*	.1393	-.3964*	.1272	-.0690	.0887
Yield				-.8127**	-.7224**	.8433**	.4748**	-.7566**	.6585**	-.8063**
Protein					-.7881**	-.5849**	-.5287**	.6486**	-.5700**	.7598**
Test weight						.4873**	.6081**	-.3537*	.4406**	-.6603**
Tiller number							.3015	-.7675**	.6080**	-.7171**
100 seed weight								-.1095	.4074*	-.5032**
Flowering date									-.5844**	.5980**
Plant height										-.6320**
Weeds										
					Pioneer HR915A					
Seeding rate		0.0	.6732**	-.5390**	.3870*	.5986**	.6044**	.3291*	.4614**	-.8523**
Nitrogen rate			-.1791	.5768**	-.4099	.2024	-.5463**	.0114	.1614	.1221
Yield				-.6635**	.7948**	.5381**	.6669**	-.4210**	.4031*	-.7817**
Protein					-.7713**	-.2904	-.8393**	.2373	-.3035	.6649**
Tbst weight						.0066	.8229**	-.2293	.1005	-.4484**
Tiller number							.1576	-.6686**	.7744**	-.6021**
100 seed weight								-.0482	.1690	-.6975**
Flowering date									-.5605	.4182**
Plant height										-.5805**
Weeds										

Table 9. (continued)

	Seeding Rate	Nitrogen Rate	Yield	Protein	Test+ Weight	Tiller Number	100 Seed Weight	Flowering Date	Plant Height	Weeds
					Prairie Valley 4450					
Seeding rate		0.0	.7567**	-.3002	.5626**	.6703**	.3849*	-.2365	.3634*	-.8182**
Nitrogen rate			-.1080	.6874**	-.4947**	.1405	-.6051**	.2185	-.0216	.1497
Yield				-.5144**	.6155**	.7826**	.4113**	-.4702**	.6483**	-.7489**
Protein					-.5858**	-.2116	-.6657**	.2991	-.2244	.3922*
Test weight						.3048	.8021**	-.2088	.0889	-.5564**
Tiller number							.1780	-.4728**	.7537**	-.6587**
100 seed weight								-.0186	.0980	-.5572**
Flowering date									-.5394**	.1854
Plant height										-.3646*
Weeds										

+ 1977 data only

*, ** Significant at the 0.05 and 0.01 levels, respectively

Test weight increased as seeding rate increased for all varieties in Manhattan at the late date. Lancota, Pioneer HR 915A and Prairie Valley 4450 showed a highly significant negative correlation between test weight and nitrogen rate and a significant and negative correlation between the two for Funk W-335. Test weight increased as yield increased for all varieties. Test weight increased as tiller number increased for Funk W-335 and Plainsman V only. Correlation between test weight and 100-seed weight was highly significantly positive for all varieties except Sage. Flowering date and test weight were highly significantly negatively correlated for Plainsman V and significantly negatively correlated for Funk W-335. Test weight and plant height were highly significantly positively correlated for Funk W-335 and Plainsman V. As weeds increased, test weight decreased for all varieties.

Weed infestation decreased as seeding rate increased for all varieties in Manhattan at the late seeding date. Yield increased for all varieties as weeds decreased. Weeds and protein percentage were significantly and positively correlated for Prairie Valley 4450 and highly significantly and positively correlated for the other six varieties. Weeds and test weight were highly significantly and negatively correlated for all varieties. As tiller number increased, weeds decreased for all varieties. Correlation between weeds and 100-seed weight was negative and highly significant for all varieties but Sage. As flowering date was delayed, weeds increased for all varieties but Prairie Valley 4450 and, as plant height increased, weeds decreased for all varieties.

The high protein varieties, Lancota and Plainsman V, showed characteristic correlations for flowering date and protein that were attributable to plant type. The semidwarf varieties, Funk W-335 and Plainsman V, showed distinctive correlations between test weight and tiller number and test weight and plant height that were attributable to their plant type.

Response of grain yield, grain protein percentage and test weight to seeding and nitrogen rates at Manhattan at the late seeding date are shown for each variety in Figures 13, 14 and 15, respectively. Grain yield was usually high regardless of nitrogen rate and it increased with increased seeding rate. Protein percentage increased with increased nitrogen rate but decreased with increased seeding rate. Funk W-335, Plainsman V and Prairie Valley 4450 had high test weight at all nitrogen levels. Test weight of Trison increased with increased nitrogen rate and test weight of Sage decreased with increased nitrogen rate. Pioneer HR 915A test weight was high at the low nitrogen rates and at the highest nitrogen rate while Lancota had high test weight at the lowest nitrogen rate and at medium-high nitrogen rates. Test weight of Trison, Sage, Prairie Valley 4450 and Lancota were generally high at all seeding rates while Funk W-335 and Plainsman V had high test weight at medium low and at high seeding rates. Test weight increased from the low through the medium seeding rates for Pioneer HR 915A.

Analysis of variance for grain yield, grain protein percentage and test weight over all three seeding dates in Manhattan for 1976 and 1977 are shown in Table 10. Grain yield and protein percentage were highly significantly affected by seeding date, variety and treatment; the interactions of date by variety and date by treatment were highly significant. Protein percentage was also highly significantly affected by the variety by treatment interaction. Test weight was affected significantly by seeding date and variety and highly significantly affected by treatments. The only interaction was date by treatment; it was highly significant.

Grain yield, grain protein percentage and test weight means for each seeding date at Manhattan over all varieties, treatments and years are given in Table 6. Yield was significantly higher at the early and normal seeding dates than at the late seeding date. Protein percentage at the late seeding

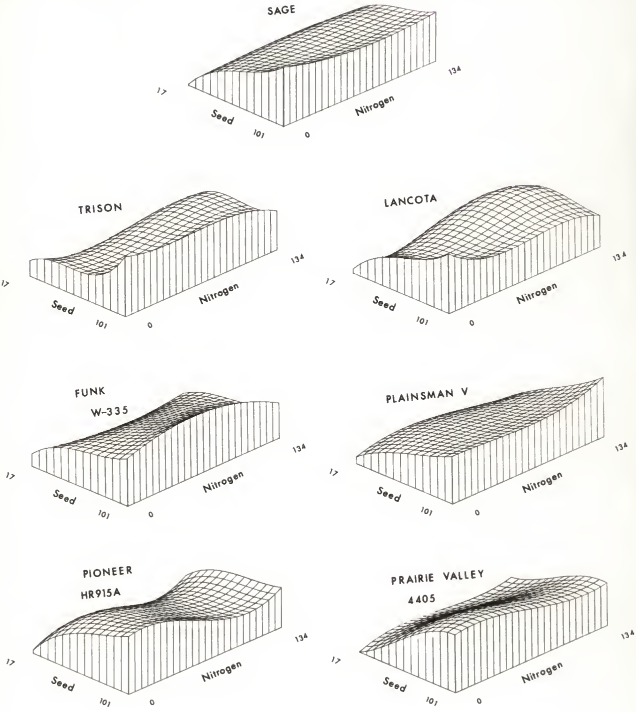

Figure 13. Seeding rate and nitrogen rate effects on grain yield of seven wheat varieties seeded at a late date in Manhattan during 1976 and 1977.

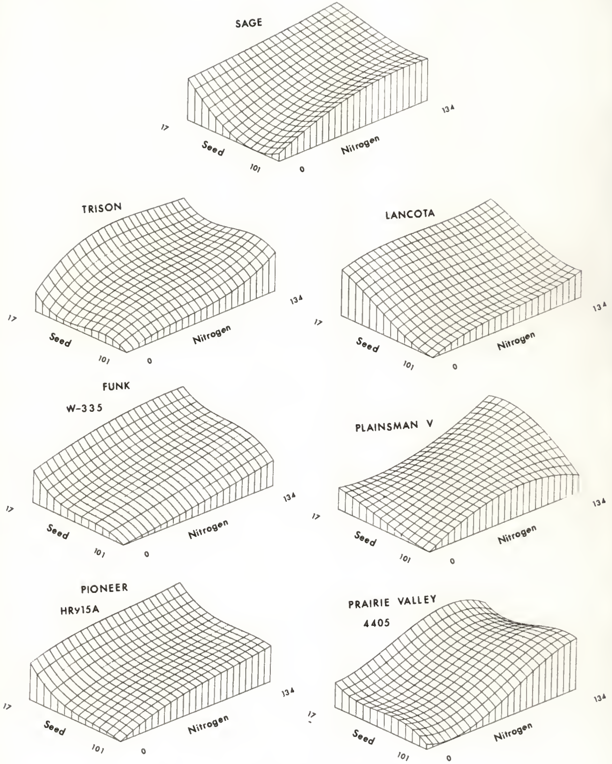

Figure 14. Seeding rate and nitrogen rate effects on grain protein concentration of seven wheat varieties seeded at a late date in Manhattan during 1976 and 1977.

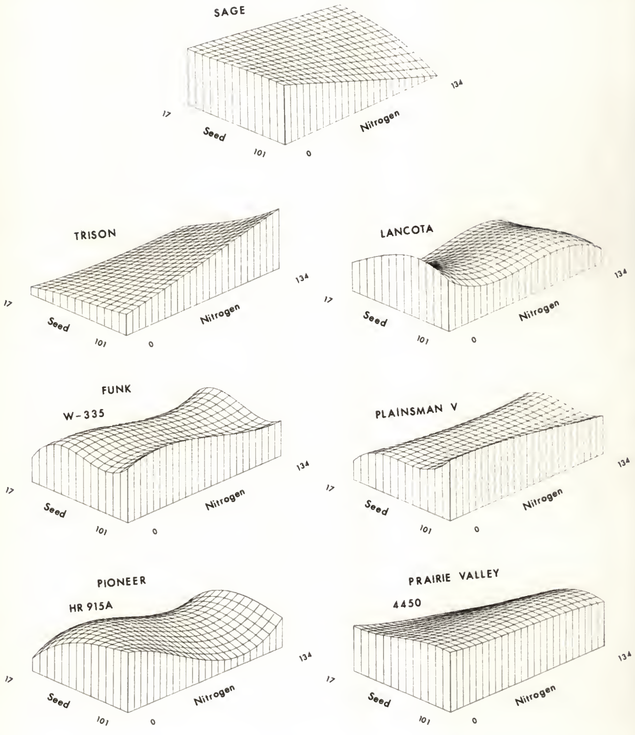

Figure 15. Seeding rate and nitrogen rate effects on test weight of seven wheat varieties seeded at a late date in Manhattan during 1976.

Table 10. Analysis of variance for grain yield, protein percentage and test weight at Manhattan over all varieties, treatments, seeding dates and years.

Source of Variation	d.f.	Mean Squares Yield	Protein	Test Weight+
Dates	2	52249445.65**	321.99**	25543.97*
Error D	4	1215309.07	2.60	2897.86
Variety	6	7321867.59**	53.23**	2520.13*
DXV	12	1464161.12**	4.28**	1172.99
Error V	36	284737.33	1.49	945.80
Treatment	12	4465520.83**	48.07**	1682.46**
DXT	24	1091003.50**	3.20**	1321.91**
VXT	72	184524.32	1.48**	159.99
DXVXT	144	160245.02	0.97	179.50
Error T	504	156788.45	1.05	200.42

*, ** Significant at the .05 and .01 levels, respectively

+ 1976 data only

date was significantly higher than the protein percentage at the early and normal dates while the normal seeding date protein percentage was significantly higher than that at the early seeding date. Test weight was significantly higher at the early and normal seeding date than at the late seeding date.

Levels of Varietal Response

The primary objective of this study was to determine response of different wheat plant types to management practices, not relative yield levels of the different varieties and hybrids. However, relative yielding ability of the different types is of interest to producers, researchers and extension specialists. For that reason, yield and other plant responses are summarized here.

Yield protein percentage and test weight means for each variety at each location and seeding date are given in Appendix Table 1. No particular plant type excelled at all locations under all conditions. The standard variety, Sage, had a medium yield level relative to the other entries at Hutchinson and Colby. At Manhattan, it yielded high when planted at the early date and it yielded medium when planted at the normal or late dates.

The two early maturing varieties, Plainsman V and Trison, had medium yield levels at Hutchinson. One early maturing variety had a low yield level and the other a medium yield level at Colby and at Manhattan at each of the three seeding dates.

The semidwarf varieties, Funk W-335 and Plainsman V, produced medium yield levels at Hutchinson while one had a medium yield level and the other a low yield level at Colby. One of the semidwarfs yielded at a medium level when seeded at the normal and early dates and yielded at a high level when seeded late in Manhattan. The other semidwarf variety yielded low relative to the other relative to the other entries at all three seeding dates in Manhattan.

Yields of the two high protein varieties, Lancota and Plainsman V, had little relationship to their grain protein percentage. One produced a low level of yield in Hutchinson and a medium yield level in Colby while the other was just the opposite. One high protein variety yielded low at all seeding dates in Manhattan. The other also yielded low when seeded at the normal and late dates but had a medium level of yield when seeded at an early date. It should be noted here that yields of one of the entries, Plainsman V, which possessed three attributes of interest -- early maturity, semidwarf stature, and high protein percentage -- were decreased by a late spring freeze on May 8, 1976.

The two hybrid wheats, Pioneer HR 915A and Prairie Valley 4450, differed somewhat in yield. One had a high yield level at all locations and dates while the other yielded low in Hutchinson and Manhattan at the early and normal seeding dates and medium in Colby and Manhattan at the late seeding date. The range of grain yield levels of the two hybrid wheats suggests hybrids need further improvement.

The relative grain protein potential of the different wheat types is also of interest. The standard variety, Sage, had a medium protein percentage level relative to the other entries at Hutchinson but a low percentage level in Colby. Normal and early seeding of Sage in Manhattan resulted in a low protein level while late seeding resulted in a medium protein percentage level.

The early maturing varieties, Trison and Plainsman V, differed in their protein percentage level. One had a low protein percentage level in Hutchinson and a medium level of protein at all other locations and seeding dates. The other, also a high protein variety, had the highest level of protein relative to the other entries at all locations and dates.

The semidwarfs, Plainsman V and Funk W-335, also varied in protein percentage level. Again one, also a high protein variety, had a protein percentage

level above all other entries at all locations and dates. The other had a low level at Hutchinson and a medium level at all other locations and seeding dates.

The high protein varieties, Lancota and Plainsman V, were consistently different at all locations and dates. One always had a medium level and the other consistently had the highest protein level.

The hybrids, Pioneer HR 915A and Prairie Valley 4450, were different in protein percentage level. One had a medium level at all locations and dates. The other had a high level of protein at all locations and dates except in Hutchinson where it had a medium level.

Test weights not only varied among wheat types but also within wheat types. The standard variety, Sage, and a medium test weight level at all locations and dates.

The two early maturing varieties, Trison and Plainsman V, were different in their test weight levels. One had high test weight level at Hutchinson with a medium level at all other locations and seeding dates while the other had low level in Manhattan at the normal and late seeding dates with a medium level at all other locations and seeding dates.

Plainsman V and Funk W-335, the semidwarf varieties, varied in test weight. Both varieties had a medium level in Hutchinson, Colby and Manhattan at the early seeding date. However, one had low test weight at the other two seeding dates in Manhattan and the other a medium level at the normal date and a height level when seeded late in Manhattan.

The high protein varieties, Lancota and Plainsman V, varied in test weight level at some locations and dates. Both had a medium test weight level in Hutchinson and Colby and in Manhattan at the early seeding date. Normal and late seeding in Manhattan resulted in a low level for one high protein variety and a medium and high level respectively for the other.

Pioneer HR 915A and Prairie Valley 4450 also varied in test weight. One had high test weight at Hutchinson and at Manhattan at the normal and late seeding dates but had a medium level at Colby and at Manhattan at the early seeding date. The other hybrid had low test weight at Manhattan at the normal seeding date with a high level of test weight at the late seeding date. Test weight level was medium for this variety at Hutchinson, Colby and the early seeding date in Manhattan.

Equality Analysis

Equality test F values for each type at each location and each seeding date are shown in Table 11. The semidwarf type had highly significant F values for yield at Manhattan at the early seeding date and for test weight at Colby at the normal seeding date. The hybrids had a highly significant F value for test weight at Manhattan at the normal seeding date. The F values for test weight also were significant for the early maturing types at Colby. The high protein type showed a highly significant F value for yield at Manhattan at the late seeding date. All other F values were nonsignificant at $F_{.05}$ and $F_{.01}$.

Equality test F values for each plant type at Manhattan for all seeding dates over all treatments are given in Table 12. There was no significant type response to seeding date.

Table 11. Equality of cubic regression models.

Location	Seeding date	Plant type	Yield	Protein	Test weight
				--- F Value ---	
MANHATTAN					
	Early seeding				
		Early maturing	1.32	1.65	.97
		Semidwarf	2.95**	1.59	1.89
		High protein	1.32	1.88	1.73
		Hybrid	.55	1.29	.45
	Normal seeding				
		Early maturing	.82	1.47	1.66
		Semidwarf	.77	.66	1.77
		High protein	1.62	1.06	1.96
		Hybrid	.06	.91	2.98**
	Late seeding				
		Early maturing	1.00	.74	1.61
		Semidwarf	1.21	.88	1.87
		High protein	6.81**	1.07	1.04
		Hybrid	.39	.83	1.27
HUTCHINSON					
		Early maturing	1.21	.67	.55
		Semidwarf	.71	.51	.63
		High protein	.64	.96	.84
		Hybrid	1.53	1.00	.45
COLBY					
		Early maturing	.67	.62	2.66**
		Semidwarf	.35	.61	2.46**
		High protein	.85	.36	1.14
		Hybrid	.61	.93	.90
		$F(11,93).05 = 1.89$		$F(11,93).01 = 2.45$	

** Significant at the .01 level

Table 12. Equality of quadratic regression models.

Plant type	Yield	Protein	Test weight
		--- F Value ---	
Early maturing	2.99	0.63	0.15
Semidwarf	4.71	1.21	0.62
High protein	2.99	0.55	1.09
Hybrid	2.79	1.05	1.54
$F(4,341).05 = 5.65$		$F(4,341).01 = 13.50$	

DISCUSSION

Wheat Type Requirements

Grain yield, protein percentage and test weight responses of all seven cultivars to seeding rate and nitrogen rate were very similar. No variety by treatment interactions occurred at any location or seeding date except for test weight response at Manhattan at the late seeding date and protein response at Hutchinson. Also, there was no significant type response to seeding date in Manhattan and generally no significant type response to seeding rate and nitrogen rate at any location. The similarities among cultivars and even cultivar types made it difficult, if not impossible, to base distinctive seeding date, seeding rate and nitrogen rate recommendations on plant types. The results indicated, however, that current recommendations might well be reviewed and revised for all wheat cultivars including the standard varieties.

Highest yields of Sage at Hutchinson were obtained at the upper end of the recommended seeding rate range (50 to 84 kg/ha) (Bieberly, 1963; Anonymous, 1970; Anonymous, 1975a), and within the recommended range of nitrogen rates (34 to 67 kg/ha) (Whitney, 1974; Anonymous, 1975a).

Yield of Sage at Colby was high when seeding rates were above those normally recommended (17 to 54 kg/ha) (Bieberly, 1963; Anonymous, 1970; Anonymous, 1975a) and nitrogen rates were within the recommended range (0 to 45 kg/ha) (Whitney, 1974; Anonymous, 1975a). Recommended rates for Colby are low due to the low moisture status of Western Kansas. Extremely dry (1975) or extremely cold (1976) conditions allowed very little if any fall top growth at Colby both years. Spring moisture was more adequate. This lack of fall top growth was possibly the reason for high yields of Sage at higher seeding rates.

Seeding rates and nitrogen rates for high yields of Sage at the normal seeding date at Manhattan were within the range of rates normally recommended

(67 to 101 kg/ha seeding rates; 45 to 78 kg/ha nitrogen rates) (Bieberly, 1963; Anonymous, 1970; Anonymous, 1975a; Whitney, 1974; Anonymous, 1975a). However, somewhat lower seeding rates also produced high yields of Sage. Yield of early-seeded Sage at Manhattan was high when nitrogen rates were above those normally recommended and seeding rates were at the lower end of the normally recommended range. Early seeding probably increased the nitrogen requirements of Sage by increasing fall top growth during the prolonged period of favorable moisture and temperature conditions. Top growth of early-seeded Sage was abundant in the fall of 1975 and probably would have been in the fall of 1976 except for early dormancy due to unusually cold temperatures. Evidently, for early-seeded Sage, high nitrogen rates are required and lower seeding rates are adequate for high yield.

Seeding rates for high yield of late-seeded Sage at Manhattan were at the upper end of the normally recommended range regardless of nitrogen rate. An increase in seeding rate is normally recommended for late-seeded wheat (Kolp et al., 1973; Ferguson and Finkner, 1969; Anonymous, 1970). Late seeding allows less fall top growth because dormancy occurs soon after planting with the advent of cold late fall temperatures. Most of the plants growth and development must occur in the spring. Maturity is usually delayed as the less vigorous, smaller plants recover more slowly from the winter. This slower growth and delayed maturity result in less response than usual to nitrogen before high temperatures and low soil moisture force early senesence. Thus, nitrogen fertilizer had little effect on yield of Sage and lower rates could be recommended with late seeding.

No distinctive wheat type yield response to seeding rate or nitrogen rate was observed at Hutchinson and Colby. All wheat plant types likewise responded similarly to seeding dates in Manhattan. However, at Manhattan, the semidwarf varieties had a distinctive response to seeding rate and to nitrogen rate at

the early seeding date and the high protein varieties had a distinctive response to seeding rate and nitrogen rate at the late seeding date.

Early-seeded semidwarf varieties in Manhattan had high yields within the normally recommended seeding rate and nitrogen rate ranges. They had slightly higher seeding rate requirements and lower nitrogen fertilizer requirements than Sage. Early seeding might decrease the apparent tillering capacity advantage of the semidwarf varieties since all varieties have the time and moisture for high tillering. The semidwarf varieties could require less nitrogen because they are shorter and have a higher harvest index (McNeal et al., 1971). Less intra-plant competition with the semidwarf varieties might allow higher seeding rates for high yield. The semidwarf varieties had higher weed competition, probably because of their short stature. This competition was worse at the lower seeding rates and could play a role in the higher yields of the semidwarf varieties with higher seeding rates.

Late-seeded high protein varieties had high yields with seeding rates somewhat above those normally recommended when the nitrogen rates were within the normally recommended range. Thus, they required a higher nitrogen rate and the same higher seeding rate that Sage also required. The high protein varieties responded more than Sage to nitrogen even at the late seeding date. Perhaps high grain protein percentage increased their nitrogen fertilizer requirement relative to that of Sage. This response to nitrogen further delayed maturity and resulted in low 100-seed weight. The grain was shriveled and the test weight decreased with increased nitrogen rate.

Current seeding rate and nitrogen rate recommendations have been made for high yield. Since yield and protein percentage are often inversely related for the standard varieties (Hucklesby, 1970), the current recommendations would not be expected to result in high protein percentage of the standard varieties. However, Smika and Greb (1973) found that even standard varieties can have high

yield and high protein percentage if both moisture and nitrogen fertility are available and properly managed.

High protein percentage of Sage at Hutchinson was obtained at seeding rates that were within or above the normally recommended range and at nitrogen rates that were above or well above those normally recommended. The high nitrogen, besides possibly stimulating protein synthesis, also delayed maturity which resulted in poor grain fill, low test weight and low 100-seed weight, which further increased protein percentage.

At Colby, high protein percentage of Sage was obtained with higher nitrogen rates than are normally recommended over a wide range of seeding rates. The factors that caused high grain protein percentage were likely similar at Colby and Hutchinson. Also, fall conditions at Colby both years in effect equalled late seeding conditions. With such conditions, grain fill is usually poor and protein percentage is high at all seeding rates.

Sage had high protein percentage at Manhattan with the currently recommended seeding and nitrogen rates at the normal seeding date. When it was seeded early or late, however, Sage required nitrogen rates above those normally recommended and seeding rates slightly below or within the recommended range. Early seeding encouraged plentiful top growth and maturation occurred when there was enough moisture and cool temperatures for good grainfill. High nitrogen rates were needed for enough uptake or translocation of enough nitrogen into the well-filled grain to maintain high protein percentages.

Grain protein percentage of all the wheat plant types responded similarly to seeding date, seeding rate and nitrogen rate.

Test weight is important to the farmer who markets his wheat. It often is recorded experimentally, but has been considered infrequently in determining seeding rate, nitrogen rate and seeding date recommendations. Generally, varieties with consistently low test weight are not recommended. High test

weight is usually associated with plump, well-filled, smooth-skinned grain (Pushman and Bingham, 1975). However, test weight has also been shown to be negatively correlated with protein percentage (Pushman and Bingham, 1975) with the highest protein percentages often found in shriveled grain. These physical characteristics all depend upon grainfill which is influenced by such factors as carbohydrate supply and transport but even more greatly by environment during grainfill. The effects of environment and management on the other components of yield - number of heads, seed size and kernel number - also affect test weight. The complexity of test weight and its maintenance is due mainly to an agronomically uncontrollable factor -- environment.

High test weight of Sage in Hutchinson was associated with seeding rates at the upper end or slightly above the normally recommended rates regardless of nitrogen rate. Conditions in Hutchinson were conducive to good grainfill even with the higher seeding rates.

Sage also required a higher seeding rate for high test weight than it normally recommended at Colby. Fall top growth was limited at Colby both years. However, the moisture was adequate and temperatures were favorable both springs, allowing good grain fill and high test weight even at the higher seeding rates. Because conditions at Colby so closely resembled late seeding, there was no differential response to nitrogen.

Seeding rate and nitrogen rate treatments did not affect test weight at Manhattan at the normal seeding date. Conditions were good for high test weight no matter what seeding rate or nitrogen rate was used. High test weight of early-seeded Sage at Manhattan required a slightly lower seeding rate than is normally recommended regardless of nitrogen rate. High seeding rates at the early date must have produced too many tillers to be well supported for grain fill. Sage also required a lower seeding rate when it was seeded late at Manhattan regardless of nitrogen rate. Late seeding caused poor grain fill and

low test weight especially when the seeding rate was high. Once again, Sage showed no response to nitrogen when it was seeded late.

There were no distinct plant type responses in terms of test weight to seeding date in Manhattan. However, there were distinct plant type responses in terms of test weight to seeding rate and nitrogen rate. The early maturing varieties and the semidwarf varieties responded distinctly to seeding rate and nitrogen rate at Colby and the hybrids responded distinctly to seeding rate and nitrogen rate at Manhattan at the normal seeding date.

The early maturing varieties had high test weight at Colby with slightly higher seeding rates and higher nitrogen rates than are normally recommended. Thus, they required a higher nitrogen rate than Sage for high test weight. The early maturing varieties would be expected to have an advantage for good grain fill and high test weight especially when spring maturation was delayed by the poor conditions during the fall of each year. The advantage would be even greater if there was a response to nitrogen fertilizer.

The semidwarf varieties had high test weight at Colby with seeding rates that were higher than normally recommended and nitrogen rates that were slightly below or within the recommended range. Nitrogen rate was more important to test weight of the semidwarf varieties than to Sage, which had high test weight regardless of nitrogen rate. It appeared the semidwarf varieties responded more to nitrogen then Sage at Colby.

Although test weight was not significantly affected by seeding rate and nitrogen rate at Manhattan at the normal seeding date, the hybrids had a distinct type response to seeding rate and nitrogen rate. The fact that the hybrids had consistently higher test weights than Sage at all seeding rate and nitrogen rate treatments could be an explanation.

Wheat Type Characteristics

The advantage of early maturity in wheat is the utilization of soil moisture for growth, development and grain fill before it becomes limiting and summer temperatures soar (Anonymous, 1976). Nitrogen rates currently recommended for the standard varieties might delay maturity and reduce the benefits of early maturity. Better use of soil moisture by early maturing types might also support higher seeding rates. Late seeding of early maturing varieties could also reduce the benefits of early maturity. Ferguson and Finkner (1969) found that heavier seeding rates benefited both early and medium maturity varieties when they were seeded late.

Generally, nitrogen rates only slightly delayed maturity of the early maturing varieties and Sage. Higher seeding rates were supported by both Sage and the early maturing varieties. High seeding rates were not more advantageous for the early maturing varieties than for Sage except with a late seeding date. Even so, that advantage over Sage was not marked. As suggested by Ferguson and Finkner (1969) and Ketata et al. (1976), yield did not differ significantly between varieties with differing maturities with the exception of Plainsman V, which yielded significantly lower than Sage at Colby and Manhattan at the late seeding date. The adverse effects of the May 1976 frost on yield of Plainsman V should be considered. In accordance with Ketata et al. (1976), the early maturing varieties and Sage differed significantly in protein percentage and kernel weight at all dates and locations and in maturity and plant height except at the normal seeding date at Manhattan.

High yield of early maturing varieties is attributed to better grain fill which could mean more protein dilution and therefore lower protein percentage of the grain. The high protein, early maturing variety, Plainsman V, appears to be an exception. Smika and Greb (1973) claim high yield and high protein percentage can be obtained if enough moisture and nitrogen are available.

Since early maturing varieties usually develop under higher moisture conditions, with proper fertility both yield and protein percentage could be high. Ferguson and Finkner (1969) found yield of early maturing varieties decreased as seeding date was delayed which could indicate increased protein percentage.

Together, the early maturing varieties were consistently higher than Sage in protein percentage. Trison alone was not significantly higher than Sage in protein percentage while Plainsman V was always highly significantly higher than Sage in protein percentage. The early maturing varieties had high yield and protein percentage with high nitrogen rates at all locations and dates even under moisture stress conditions at Colby and at Manhattan at the late seeding date. Yield was lower and protein percentage higher at the late seeding date for Sage and the early maturing varieties.

Early maturing varieties might be expected to have high test weights as they usually mature and fill grain under more favorable moisture and temperature conditions. Late seeding of early maturing varieties might decrease the advantage of early maturity and result in lower test weights.

Test weight of Plainsman V and Sage were similar at Colby and Hutchinson but not at Manhattan, indicating that the May frost in 1976 could have caused its low test weight there. Late seeding did result in lower test weights of the early maturing varieties and Sage.

Semidwarf wheats were developed to allow high nitrogen fertility without lodging (McNeal et al., 1971; Hunter and Stanford, 1973; Lupton, 1975). They were reported to have higher tillering capacity (Lupton, 1975; Bradley and Vimpany, 1974; Black and Siddoway, 1977; Deckard et al., 1977). Some were even reported to be more photosynthetically efficient (Lupton, 1975). Bradley and Vimpany (1974) claimed that semidwarf varieties are more responsive to nitrogen fertility, while Black and Siddoway (1977), Hunter and Stanford (1973) and McNeal et al. (1971) found this was not the case.

The semidwarf varieties required higher nitrogen fertility than Sage for high yield at Hutchinson and Colby but not at Manhattan. Their tillering capacity was not significantly higher than that of Sage at any location or seeding date. Nitrogen fertility was significantly correlated with more factors for the semidwarf varieties than for Sage, suggesting that the semidwarf varieties were more responsive to nitrogen fertility. If seeding rates were high enough, yield of the semidwarf varieties was not depressed by high nitrogen rates; in fact, the higher nitrogen rates often produced higher yields. In most cases, the semidwarf varieties had the same nitrogen requirement for high yield as for high protein percentage.

Semidwarf variety development for high yield potential could mean low protein percentage (McNeal et al., 1971). However, semidwarf varieties have been found to have small seeds (low kernel weight) (Heyne and Campbell, 1971; Cholick, Welsh and Cole, 1977; Johnson, Schmidt and Mekasha, 1966; Black and Siddoway, 1977). This could result in high protein percentage due to less protein dilution by carbohydrates. Hucklesby (1971) found high yield and high protein percentage of semidwarf varieties when nitrogen fertility was high. Protein percentage in semidwarf varieties increased with increased nitrogen (Stanford and Hunter, 1973; McNeal et al., 1971; Laopirojana, 1972).

The semidwarf varieties had smaller seeds than Sage except when they were seeded late, in which case both the semidwarf varieties and Sage had small seeds. The smaller seed size of the semidwarf varieties did not contribute to high protein percentage through less protein dilution. One-hundred seed weight was negatively correlated with protein percentage for Sage as well as for the semidwarf varieties.

The combined high yielding and high tillering capacity of the semidwarf varieties (Lupton, 1975; Bradley and Vimpany, 1974; Black and Siddoway, 1977; Deckard et al., 1977) would suggest good grain fill under non-moisture stress

conditions. However, under moisture stress, high tillering capacity with high nitrogen rates could result in low test weight.

Tillering was greatly decreased in the semidwarf varieties and Sage when they were seeded late and was also low when they were seeded at Colby under moisture stress conditions. High nitrogen rates did not result in high test weight; they especially decreased test weight at Colby and Manhattan at the late seeding date.

High protein varieties were developed for both high yield and high protein percentage of the grain. Yield and protein are believed to have an inverse relationship (Miezan, Heyne and Finney, 1977; Johnson, 1974; and Hucklesby, 1971). However, genes for high protein potential have been found such that the protein percentage is higher than the standard varieties even though the inverse yield and protein relationship exists (Johnson, 1974; Heyne, 1974). Johnson (1974), Johnson et al. (1973) and Hucklesby (1971) all found high protein and high yield to be compatible in high protein varieties.

Johnson (1974) found high nitrogen decreased the yield of standard varieties but not high protein varieties. Olson (1974) found high protein varieties had not reached their threshold for yield or protein percentage at 135 kg/ha nitrogen, which is well above any recommendation in Kansas. Increased nitrogen increased protein percentage of the high protein varieties (Johnson, 1974; Miezan et al., 1977). Late seeding of high protein varieties could result in high protein percentage for the same reasons as the standard varieties - too little moisture for good grain fill.

The high protein varieties required higher nitrogen rates than Sage for high yield. However, Sage had an equally high nitrogen requirement for high protein percentage at Hutchinson, Colby and Manhattan at the early seeding date. Yield of the high protein varieties was still increasing at nitrogen rates well above those recommended in any area of Kansas. The high nitrogen requirement for

high yield and protein percentage of the high protein varieties did not support a higher seeding rate than was supported by the lower nitrogen requirement of Sage.

High Protein percentage of the high protein varieties has been found to be due mainly to more efficient and complete translocation of nitrogen to the grain (Johnson, 1974; Olson and Sander, 1975; Johnson et al., 1973; Wilhelmi, 1974; and Yousef and Salem, 1975). However, expression of high protein often interacts with environment (Heyne, 1977), especially nitrogen management (Johnson, 1974; Hucklesby, 1971).

The degree of expression of high protein in the high protein varieties appeared to be more dependent upon nitrogen rate than seeding rate at all locations and dates except the late seeding date in Manhattan where seeding rate became important to grain protein percentage. Protein percentage of the high protein varieties increased with increased nitrogen and was still increasing at 134 kg/ha except at Manhattan at the early seeding date where 134 kg/ha nitrogen depressed protein percentage of the high protein varieties as well as Sage.

High protein varieties supposedly allow for both high yield and high protein percentage if enough moisture and nitrogen are available. Moisture appears more directly important to yield (and therefore test weight) while nitrogen is more important to both yield and protein percentage. Moisture stress conditions could result in low test weights of high protein varieties.

Test weight of Sage and the high protein varieties was low at the late seeding date and there was no significant correlation between test weight and nitrogen rate. Moisture appeared to be the limiting factor for high test weight of all three varieties. Test weight of Sage and the high protein varieties was not lower at Colby than at Hutchinson. The moisture effect must not have been as severe. The high nitrogen rate requirement of the high protein varieties did not result in even lower test weights for the high protein varieties than for Sage at the late seeding date.

Hybrids were developed for high yield (Livers and Heyne, 1968; Hayward, 1975; Anonymous, 1976; Anonymous, 1975). Hayward (1975), Rodrigiez et al. (1967) and Livers and Heyne (1968) speculated that success of hybrids depends upon expression of heterosis for yield from crossing two varieties of diverse genetic makeup. Hybrid vigor was found to be expressed in tillering capacity (Hayward, 1975; Livers and Heyne, 1968), increased 1000-kernel weight (Jost and Milhonic, 1975) and emergence and plant vigor (Hayward, 1975).

There has been much speculation on seeding rates for hybrids. Support has been expressed for a 50% reduction in the seeding rates normally recommended for the standard varieties without a reduction in yield (Hayward, 1975). Sage (1973) found seeding rate did not affect the level of heterosis while Hayward (1975) claimed hybrids out-yielded standard varieties at low and high seeding rates; the main advantage of hybrids was at the higher seeding rates. Optimum seeding rates for hybrids could easily vary from those normally recommended for standard varieties. If there is heterosis for nitrogen response, the optimum nitrogen rate could also vary from the current recommendations. Hybrid vigor in tillering, emergence and plant vigor might decrease the detrimental effects of late seeding.

The hybrids did not show hybrid vigor in tiller number. Although the hybrids together had significantly higher 100-seed weight than Sage, this was usually due to very high 100-seed weight of Prairie Valley 4450. That hybrid appeared to have high seed weight because of poor seed set, not because of hybrid vigor. A 50% reduction in seeding rate resulted in low yield for the hybrids and Sage. However, seeding rate had a higher positive correlation to yield for Sage than for the hybrids. The hybrids had no advantage at the higher seeding rates. Late seeding reduced yield of the hybrids more than Sage. The hybrids usually required a higher nitrogen rate than Sage for high yield. Yield of the hybrids did not exceed that of the standard variety by 20% as reported by others (Anonymous, 1975; Anonymous, 1976; Livers and Heyne, 1968).

However, yield of Pioneer HR 915A was significantly higher than that of Sage in most cases. Yield of Prairie Valley 4450 was either not significantly different or significantly lower than Sage because of poor seed set.

Sage (1973), Bitzer and Fu (1972) and Jost and Milhonic (1975) found hybrids had heavier seeds than standard varieties. This could decrease the protein percentage of the hybrids by dilution of protein in the grain. If, however, hybrids express heterosis for plant nitrogen metabolism, they could have plump grain with high protein percentage also.

The hybrids did have heavier, plumper seeds than Sage but they also had significantly higher protein percentage. Prairie Valley 4450 always had high 100-seed weight while the 100-seed weight of Pioneer HR 915A was sometimes, but not always, significantly higher than that of Sage. Heterosis in nitrogen metabolism could be one reason for high protein percentage of the heavier plumper hybrid seed.

Wheat hybrids are claimed to have more plant vigor from emergence through maturity (Hayward, 1975). They have been reported to produce bigger, plumper seed (Pushman and Bingham, 1975) which could result in high test weight. Although the hybrids had plumper seeds, their test weight was not significantly higher than that of Sage.

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APPENDIX

Appendix Table 1. Grain yield, protein percentage and test weight means for each variety at each location and seeding date in 1976 and 1977.

Location	Variety	Yield	Protein	Test weight
		-kg/ha-	-%-	-kg/hl-
Hutchinson				
	Sage	3225.1	14.3	80.1
	Trison	3209.9	13.8	81.0
	Lancota	2878.9	14.5	79.2
	Plainsman V	3251.4	15.8	79.7
	Funk W-335	3289.8	13.6	80.6
	Pioneer HR915A	3633.6	14.1	82.2
	Prairie Valley 4450	3054.2	14.8	79.4
	LSD.05	346.3	0.4	1.2
Colby				
	Sage	2137.3	13.1	80.3
	Trison	2104.3	13.4	81.9
	Lancota	2106.6	13.4	80.2
	Plainsman V	1924.0	15.2	81.4
	Funk W-335	2128.0	13.4	82.7
	Pioneer HR915A	2440.4	13.7	81.7
	Prairie Valley 4450	2186.8	15.2	79.6
	LSD.05	122.8	0.8	NS
Manhattan Normal Seeding+				
	Sage	1582.8	15.2	84.8
	Trison	1582.9	15.7	85.9
	Lancota	1320.2	15.3	84.6
	Plainsman V	1091.4	17.3	81.2
	Funk W-335	1913.7	14.8	84.0
	Pioneer HR915A	2240.3	15.4	87.9
	Prairie Valley 4450	1281.1	17.0	83.0
	LSD.05	269.6	0.6	3.1
Manhattan Early Seeding+				
	Sage	1941.7	14.1	82.3
	Trison	1710.3	14.3	82.2
	Lancota	1652.5	14.6	80.7
	Plainsman V	1295.1	15.5	80.0
	Funk W-335	1561.5	14.4	80.5
	Pioneer HR915A	2003.0	14.5	82.8
	Prairie Valley 4450	1280.0	15.3	80.1
	LSD.05	296.0	0.5	NS

Appendix Table 1 (continued)

Location	Variety	Yield	Protein	Test weight
		-kg/ha-	-%-	-kg/hl-
Manhattan Late Seeding+				
	Sage	753.2	16.8	78.8
	Trison	856.8	16.7	78.3
	Lancota	647.3	16.6	76.0
	Plainsman V	727.3	17.9	75.4
	Funk W-335	955.8	16.0	79.9
	Pioneer HR915A	1123.1	16.5	79.3
	Prairie Valley 4450	873.8	17.3	79.7
	LSD.05	218.4	0.7	2.5

+ Test weight data for 1976 only

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TO PRODUCTION PRACTICES

by

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Manhattan, Kansas

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Most present winter wheat production recommendations for Kansas are based on data obtained from standard varieties. These varieties are usually mid-season in maturity, tall and have average of low grain protein percentage. Recently, new wheat plant types have been developed such as early maturing varieties, semidwarf varieties, high protein varieties and hybrids. We compared responses of the new wheat plant types and Sage, a standard variety, to the most important production factors -- seeding date, seeding rate, and nitrogen fertilization -- at Manhattan and to seeding rate and nitrogen fertilization at Hutchinson and Colby, Kansas. The objective was to determine applicability of recommended production practices based on the standard varieties to the new wheat plant types. Five varieties and two hybrids were seeded and fertilized in an incomplete factorial of five seeding rates and five nitrogen rates (13 treatments) at all three locations. In addition, three seeding dates were included at Manhattan. A split-plot design was used at Colby and Hutchinson and a split-split-plot design was used at Manhattan. The seven cultivars included Sage, a standard variety; Trison, a tall early maturing variety; Lancota, a tall medium maturing variety with high protein potential; Plainsman V, a semidwarf, early maturing, high protein variety; Funk W-335, a semidwarf medium maturing variety; Pioneer HR 915A, a medium maturing hybrid; and Prairie Valley 4450, an early maturing hybrid. Measurements included tiller number, grain yield, 100-seed weight, grain test weight and grain protein percentage at all locations. In addition, flowering date, disease infestation, percent weed infestation and plant height were measured at Manhattan. The new wheat plant types exhibited distinct yield, protein percentage or test weight responses to seeding date, seeding rate or nitrogen rate in only five cases. At Colby, the early maturing

varieties, semidwarf varieties and Sage had similar requirements for high test weight; however, the early maturing varieties and semidwarf varieties had higher test weight than Sage at low seeding rates. The semidwarf varieties had higher seeding rate requirements than Sage at Manhattan at the early seeding date. At the late seeding date, high protein varieties and Sage had similar seeding rate and nitrogen rate requirements for high yield, but the high protein varieties were more responsive to nitrogen at low seeding rates. Test weight of the hybrids was consistently higher than that of the standard variety at all seeding rate and nitrogen rate treatments. Simple correlation coefficients and surface response graphs revealed little variation in yield, protein percentage and test weight response among types and between cultivars within each type. These similarities in yield, protein percentage and test weight responses made it unnecessary to make distinctive seeding date, seeding rate or nitrogen rate recommendations for the new wheat plant types. The results indicated, however, that the current production recommendations could be reviewed and revised for the new wheat types as well as for the standard types.